



Near-Road NO₂ Monitoring

Technical Assistance Document

DRAFT

December 21, 2011

Preface

This document (released December 21, 2011) is a draft of the Near-Road NO₂ Monitoring Technical Assistance Document (TAD). The TAD is being developed to aid state and local air monitoring agencies in the implementation of required near-road NO₂ monitoring stations. Note that this is a draft document and will be subjected to further revision. This draft version of the TAD reflects some of the edits and concept adjustments suggested by the Clean Air Scientific Advisory Committee (CASAC) Ambient Monitoring and Methods Subcommittee (AMMS) stemming from a September 29, 2011 teleconference discussion of the August 9th version of the TAD, a November 17th follow-up teleconference by the CASAC AMMS, other suggested edits from multiple state and local air agencies, and edits by the EPA.

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Acknowledgments

This document reflects collaboration between multiple local, state, and federal entities who all have a stake in the implementation of required near-road NO₂ monitoring stations, along with contracted support. The EPA wishes to recognize these partners and thank them for their efforts in the conception, development, and review of this TAD, which covers a wide range of materials and concepts.

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City of Albuquerque Environmental Health Department

Hillsborough County (FL) Environmental Protection Division

Idaho Department of Environmental Quality

Maryland Department of the Environment

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State and Federal Transportation Agencies/Associations

Florida Department of Transportation

Texas Department of Transportation

U.S. Department of Transportation Federal Highways Administration

American Association of State Highway and Transportation Officials

Contract Support

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Executive Summary

On February 9, 2010, EPA promulgated new minimum monitoring requirements for the nitrogen dioxide (NO₂) monitoring network in support of a newly revised 1-hour NO₂ National Ambient Air Quality Standards (NAAQS) and the retained annual NAAQS. In the new monitoring requirements, state and local air monitoring agencies are required to install near-road NO₂ monitoring stations at locations where peak hourly NO₂ concentrations are expected to occur within the near-road environment in larger urban areas. State and local air agencies are required to consider traffic volumes, fleet mix, roadway design, traffic congestion patterns, local terrain or topography, and meteorology in determining where a required near-road NO₂ monitor should be placed. In addition to those required considerations listed above, there are other factors that impact the selection and implementation of a near-road monitoring station including satisfying siting criteria, site logistics (e.g., gaining access to property and safety), and population exposure. The purpose of this Near-Road NO₂ Monitoring Technical Assistance Document (TAD) is to provide state and local air monitoring agencies with recommendations and ideas on how to successfully implement near-road NO₂ monitors required by the new (2010) revisions to the NO₂ minimum monitoring requirements.

This document also provides information on optional or discretionary multi-pollutant monitoring in the near-road environment. The establishment of near-road NO₂ monitoring stations will create an infrastructure that will likely be capable of housing other ambient air monitoring equipment. Considering the near-road NO₂ monitoring stations for multi-pollutant monitoring, even though it may not be required, matches with the Agency's multi-pollutant paradigm, presented in the *Ambient Air Monitoring Strategy for State, Local, and Tribal Air Agencies* document published in 2008, and has been noted within documents associated with the

NO₂ NAAQS revision of 2010 and the Carbon Monoxide (CO) NAAQS review of 2011. The intent of the multi-pollutant paradigm is to encourage the integration of multiple individual pollutant monitoring networks to broaden the understanding of air quality conditions and pollutant interactions, furthering the ability to evaluate air quality models, develop emissions control strategies, and support long-term scientific studies (including health studies). In light of this potential for multi-pollutant monitoring at near-road NO₂ monitoring stations, this TAD discusses other pollutants of interest that exist in the near-road environment, including definitions, basis of interest, and measurement methods.

Section 1. Background and Near-Road NO₂ Network Objectives

On February 9, 2010, new minimum monitoring requirements for the nitrogen dioxide (NO₂) monitoring network were promulgated (75 FR 6474) in support of a revised National Ambient Air Quality Standard (NAAQS) for NO₂. The NO₂ NAAQS was revised to include a 1-hour standard with a 98th percentile form and a level of 100 ppb, reflecting the maximum allowable NO₂ concentration anywhere in an area, while retaining the annual standard of 53 ppb. In the latest NO₂ Risk and Exposure Assessment (found at http://www.epa.gov/ttn/naaqs/standards/nox/s_nox_cr_rea.html) created during the NAAQS revision process, and as reiterated in the preambles to the Notice of Proposed Rulemaking (NPR for NO₂) (74 FR 34404) and the Notice of Final Rulemaking (NFR for NO₂) (75 FR 6474) on the Primary NAAQS for NO₂, the EPA recognized that roadway-associated exposures account for a majority of ambient exposures to peak NO₂ concentrations.

In the rulemaking process leading to the recent NO₂ NAAQS revision, it was established that the combination of increased vehicle-miles-traveled (VMT), which correspond to on-road mobile source emissions, with higher urban population densities can result in an increased potential for exposure and associated risks to human health and welfare. In the NPR for NO₂, when proposing the level of the revised NO₂ NAAQS, the Administrator noted that “the available evidence and analyses support the importance of roadway-associated NO₂ exposures for public health. Specifically, the exposure assessment presented in the REA¹ estimated that roadway-associated exposures account for the great majority of exposures to peak NO₂ concentrations

¹ The REA is the EPA’s *Risk and Exposure Assessment to Support the Review of the NO₂ Primary National Ambient Air Quality Standard* (U.S. Environmental Protection Agency, 2008a).

(REA, Figures 8-17 and 8-18).” In the NPR, the EPA clearly states that the populations included in that assessment were people who live, work, play, or go to school near major roads, as well as those people who spend time commuting on major roads (74 FR 34419). Ultimately, the Administrator followed through on the proposed approach to setting the level of the NO₂ NAAQS, and promulgated a revised NO₂ NAAQS that has a high degree of confidence in providing appropriate public health protection by limiting the higher short-term peak exposure concentrations expected to occur on and near major roadways, as well as the lower short-term exposure concentrations expected to occur away from those roadways.

The EPA promulgated requirements for near-road NO₂ monitors in urban areas in conjunction with the NO₂ NAAQS revision. The primary objective of the required near-road NO₂ network is to support the Administrator’s approach in revising the NO₂ NAAQS discussed above by focusing monitoring resources on near-road locations where peak, ambient NO₂ concentrations are expected to occur as a result of on-road mobile source emissions. Monitoring at such a location or locations within a particular urban area will provide data that can be used for comparison to the NAAQS and to assess population exposures to those who live, work, play, go to school, or commute within the near-roadway environment. The near-road NO₂ data will provide a clear means to determine whether or not the NAAQS is being met within the near-road environment throughout a particular urban area. Since near-road NO₂ monitoring sites are to be placed at locations with expected peak NO₂ concentrations, and the target mobile sources and the roads they travel upon are ubiquitous throughout urban areas, these monitoring data may be said to represent the relative worst case population exposures that may be occurring in the near-road environment throughout an urban area over the averaging times of interest.

Requirements for near-road monitors are based upon population levels and a specific traffic metric within Core Based Statistical Areas (CBSAs). State and local ambient air monitoring agencies are required (per 40 CFR Part 58 Appendix D, Section 4.3.2.a) to use the latest available census figures (e.g., census counts and/or estimates) and available traffic data in assessing what may be required of them under this new rule. Further, state and local air agencies are required to consider traffic volumes, fleet mix, roadway design, traffic congestion patterns, local terrain or topography, and meteorology in determining where a required near-road NO₂ monitor should be placed. In addition to those required considerations listed above, there are other factors that impact the selection and implementation of a near-road monitoring station including satisfying siting criteria, site logistics (e.g., gaining access to property and safety), and population exposure. The required near-road NO₂ monitoring network is to be implemented and operational by January 1, 2013. State and local ambient air monitoring agencies are required to submit their plans for any required near-road NO₂ monitoring stations in their annual monitoring network plans due July 1, 2012.

The EPA believes that the site selection requirements and siting criteria for near-road NO₂ monitoring stations (presented in the Code of Federal Regulations [CFR] and reiterated in this TAD), provide sufficient flexibility to state and local air agencies for near-road NO₂ monitoring site implementation. This flexibility should allow state and local air agencies to balance the over-arching objective of placing monitor probes “as near as practicable” to highly trafficked roads where peak NO₂ concentrations are expected to occur with the variety of site implementation issues that exist in the real world. As such, the EPA strongly encourages states and local agencies to exercise due diligence in selecting and installing required near-road NO₂

monitoring stations, providing sound rationale of their decisions in light of the intention of the network design.

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Section 2. Near-Road NO₂ Monitoring Technical Assistance Document Objectives

During the public comment period on the proposed NO₂ rulemaking, and upon the promulgation of the final NO₂ rulemaking that requires the near-road NO₂ monitoring network (75 FR 6474), the EPA received feedback from the air monitoring community requesting further clarification and/or assistance on how the required near-road NO₂ network might best be implemented. The EPA responded with a commitment to provide assistance through the form of this Near-Road NO₂ Monitoring TAD. The purpose of this TAD is to provide recommendations and ideas on how to successfully install near-road NO₂ monitors required by the recent revisions to the NO₂ monitoring requirements in 40 CFR Part 58 Appendices D and E.

The primary objective of this TAD is to provide a set of options, including technical approaches and rationale, for the near-road NO₂ monitoring site selection process to assist state and local air monitoring agencies in implementing required near-road NO₂ monitoring stations in a manner that satisfies the requirements and intent of 40 CFR Part 58.

The material supporting this objective is primarily contained in Section 3 through Section 14 of this document. Section 15 presents information on selecting a second near-road monitoring site. Section 16 presents information on other pollutants of interest in the near-road environment, which are not required to be measured unless noted otherwise, but are recommended to address scientific and policy relevant issues. The characterization of these other pollutants and metrics can broaden the understanding of air quality conditions and pollutant interactions (particularly in the near-road environment), furthering the ability to evaluate air quality models, develop emissions control strategies, and support long-term scientific studies (including health studies). The information provided about these other pollutants or metrics of interest includes definitions, reason for interest, and measurement methods. In addition to the

body of this TAD, the appendices provide a variety of supporting information and data. Finally, the EPA notes that the recommendations in this TAD should not be construed as requirements (requirements are contained within 40 CFR Part 58), but rather technically-appropriate approaches to implement required near-road NO₂ monitoring stations.

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Section 3. Identifying Core Based Statistical Areas with Required Near-Road Monitoring

The first step in implementing required monitoring is for state and local ambient air monitoring agencies to identify the extent to which the monitoring requirements apply to their respective territories. Specifically, in 40 CFR Part 58 Appendix D, the EPA requires state and local air agencies to operate one near-road NO₂ monitor in each Core Based Statistical Area (CBSA) with a population of 500,000 or more persons. Further, those CBSAs with 2,500,000 or more persons, or those CBSAs with one or more roadway segments carrying traffic volumes of 250,000 or more vehicles (as measured by annual average daily traffic [AADT] counts), shall have two near-road NO₂ monitors. State and local ambient air monitoring agencies are required to use the most up-to-date census information and traffic data in assessing what may be required of them under this rule, per 40 CFR Part 58 Appendix D, Section 4.3.2.a. The process of identifying minimum monitoring requirements is shown in **Figure 3-1**.

Identify Minimum Monitoring Requirements

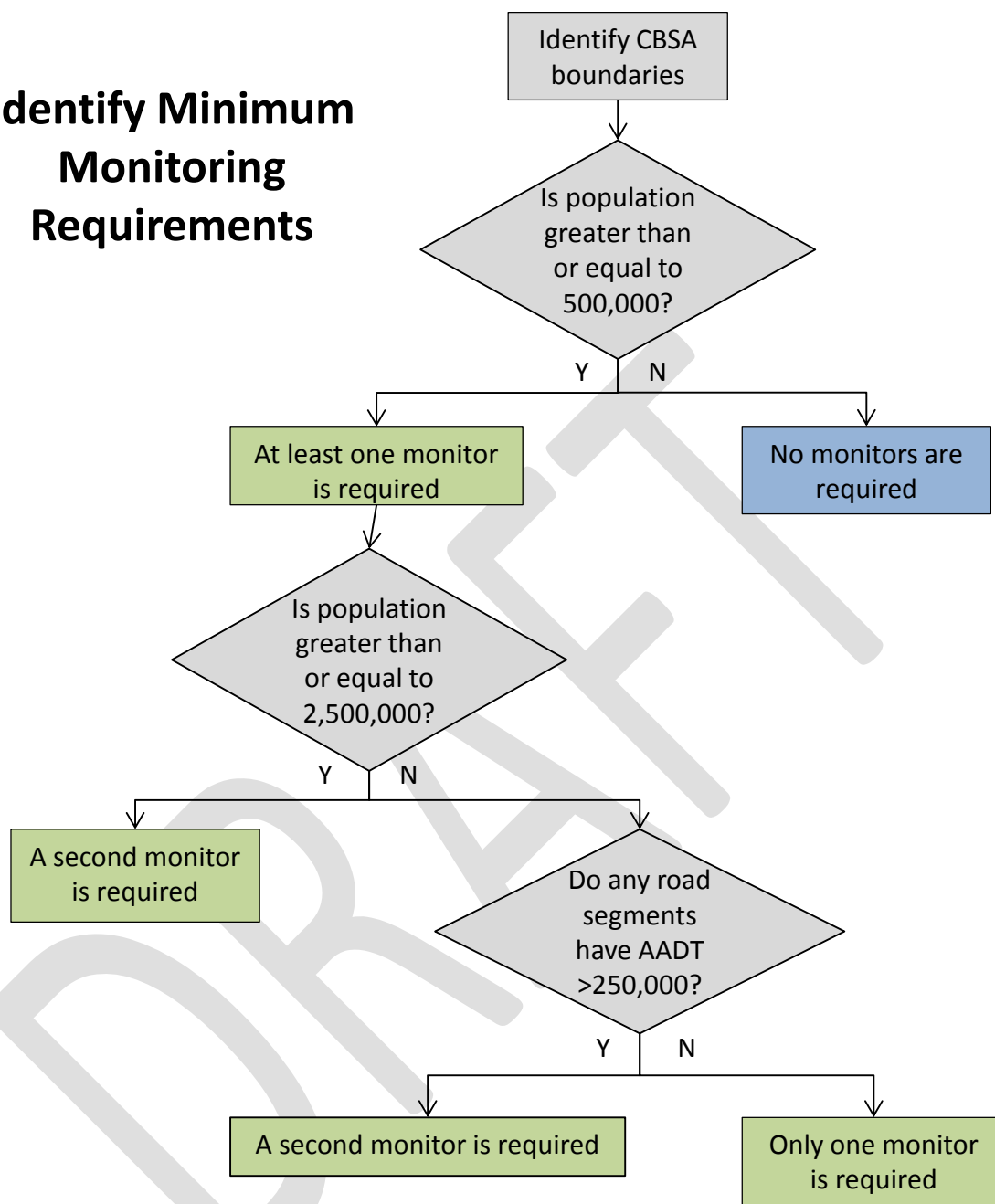


Figure 3-1. Flowchart illustrating the process of identifying whether minimum monitoring requirements for near-road NO₂ monitors apply to individual core based statistical areas (CBSAs).

3.1 Identifying CBSA Boundaries

CBSAs are made up of whole counties, which may or may not all be within the same state. CBSA is a collective term for both micropolitan and metropolitan statistical areas². Micropolitan (micro) and metropolitan (metro) statistical areas, and thus CBSAs, are geographic entities defined by the U.S. Office of Management and Budget (OMB) for use by Federal agencies in collecting, tabulating, and publishing Federal statistics, such as population.

A micro area contains an urban core in a county or counties of at least 10,000 people, but fewer than 50,000, while a metro area has one or more counties containing a core urban area of 50,000 people or more. Each micro or metro area consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core (U.S. Census Bureau, 2005). A full explanation of the development and application can be found in the *Federal Register*; specifically, “Standards for Defining Metropolitan and Micropolitan Statistical areas; Notice” (Office of Management and Budget, 2000).

The list of CBSAs, along with associated population data and estimate information, is conveniently available on the web from the U.S. Census Bureau (see Section 3.2). The use of CBSAs to define areas where near-road monitoring is to occur is appropriate because they account for populations within core urban areas and their surrounding communities. These areas are affiliated socially and economically as measured by commuting patterns that offer a direct relation between traffic and population. Further, because CBSAs include more than just the core urban areas, it is highly unlikely that roads with high total traffic volumes or high truck (or

² Typically, in ambient air monitoring, metropolitan statistical areas are synonymous with the acronym MSA.

heavy-duty vehicle) traffic counts that are not located in the immediate vicinity of a core urban area would be overlooked and/or excluded in the consideration process for near-road monitoring.

3.2 Identifying Census Data

The EPA recommends that states and local air agencies use the U.S. Census Bureau as the source of their population estimates. A convenient list of CBSAs and their estimated populations have historically been available on the Census Bureau's website in the population estimate section (<http://www.census.gov/popest/metro/metro.html>). However, the Census Bureau is now encouraging the public to use the American Fact Finder for population-related information at <http://factfinder.census.gov>. The American Fact Finder can be used to locate population counts and demographic information for a CBSA, including data collected during the recent 2010 census. In addition to whole CBSA populations, information is also available at different geographic levels, such as block, block group, and census tract. The geographic boundaries of these levels can be found within reference maps on the American Fact Finder website.

3.3 Identifying Roadway Traffic Volumes in Excess of 250,000 AADT

The EPA recommends that state and local air agencies obtain traffic volume data from a state or local Department of Transportation (DOT), other local entities such as metropolitan planning organizations (MPOs), or from the U.S. DOT for the most up-to-date traffic information available, including AADT data. These data can then be analyzed to ascertain whether one or more road segments in a CBSA have an AADT count of 250,000 or greater, which would warrant a second near-road monitor if that CBSA has a population less than 2,500,000 persons. Section 5.2 provides a list of recommended sources for traffic volume data in the form of AADT.

3.4 Meeting Requirements in CBSAs Covering Multiple Geo-Political Boundaries (Multi-Agency/Multi-State)

In a number of cases, a CBSA may cover more than one state and/or cover an area shared by more than one air monitoring agency. In such cases, state and local air agencies are encouraged to engage each other, including all of the affected parties, in determining where any near-road monitoring may be conducted. These discussions are most helpful if conducted before and during the traffic data analysis process and while determining an initial list of candidate road segments (discussion starting in Section 6). This process will ensure that all parties are aware of the most appropriate road segments to focus upon for identifying candidate near-road monitoring sites. Further, it is strongly advised that state and local agencies engage associated EPA Regional staff in identifying ways in which multiple air monitoring agencies can collaborate to satisfy minimum monitoring requirements for individual CBSAs.

While EPA Regional staff should be readily available for consultation and participation in this process, the state and local air agencies are expected to take the lead on the decision making. One suggested result of this collaboration should be the inclusion in each affected party's annual monitoring network plan of the location of all required near-road NO₂ monitors for a given CBSA, regardless of the operating air agency.

Section 4. Near-Road NO₂ TAD Quick-Start

This section is a quick-start guide to the TAD, providing a short, simplified summary of what is required by rule and the ideas and approaches state and local air agencies may take to implement required near-road NO₂ monitoring sites. This quick-start section highlights key points presented throughout this TAD; the rationale and supporting details for each key point are contained in the respective subsequent sections of this document as noted.

4.1 AADT, Fleet Mix, and Congestion Data

Figure 4-1 presents a flow chart outlining steps to develop a relatively prioritized list of potential candidate road segments based on available AADT, fleet mix, and congestion data for an entire CBSA.

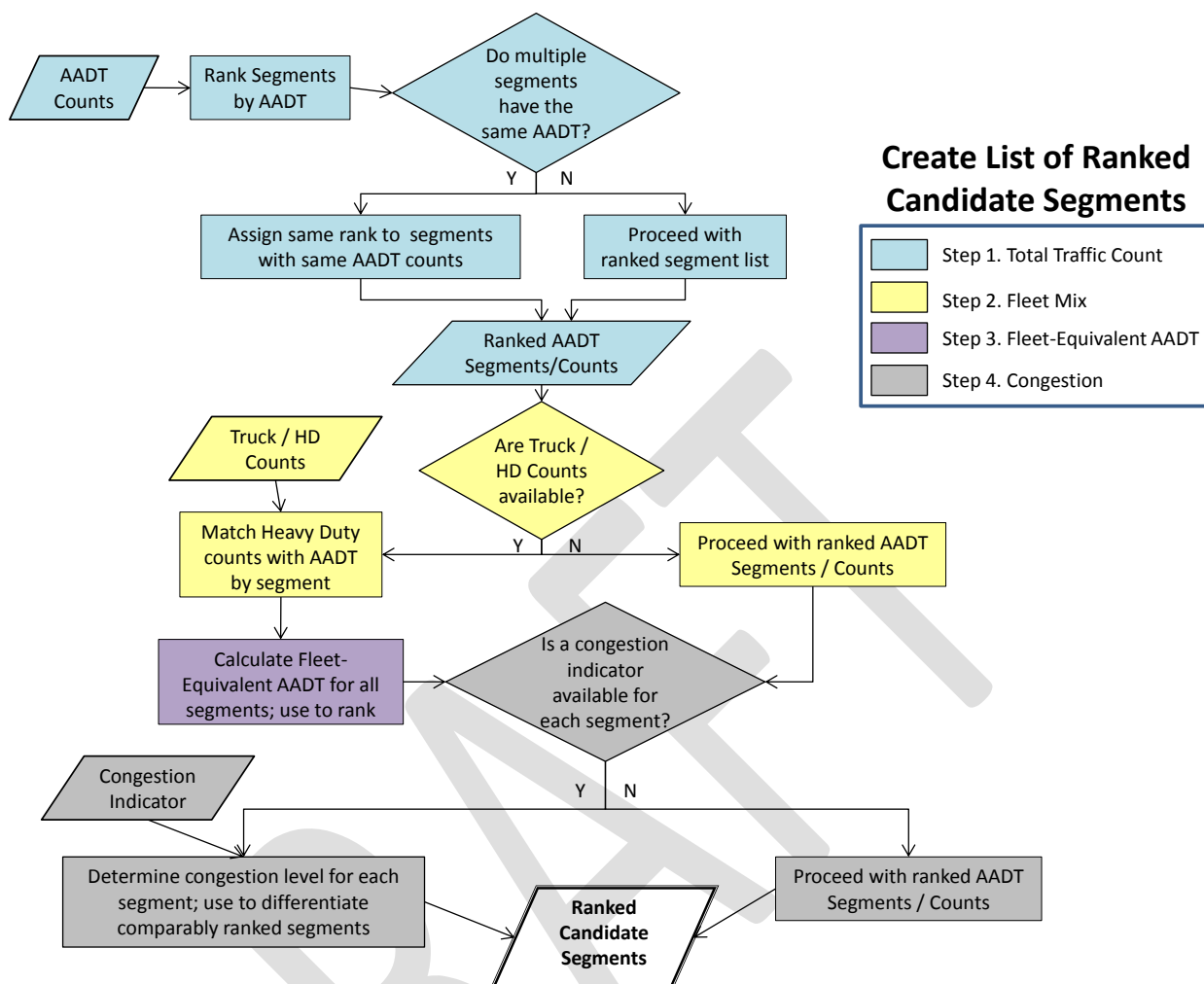


Figure 4-1. Candidate road segment ranking process. This flowchart presents the traffic data evaluation process to provide a prioritized list of candidate road segments (accounting for traffic volume [AADT], fleet mix, and congestion) for further evaluation as potential near-road NO₂ monitoring stations.

Table 4-1 presents a summary of traffic information to be used in near-road NO₂ monitoring site consideration. By using the flow chart steps, road segments are to be ranked from highest to lowest fleet equivalent (FE) AADT value to start the site selection process. A complete introduction to the sources, interpretation, and use of these traffic data are presented and discussed in Section 5.

Table 4-1. Summary of the traffic-related metrics for candidate site consideration.

Component	Rationale	Potential Sources
AADT	Focus on locations with high traffic volumes	State DOT, local/MPO, or US DOT's HPMS
Fleet mix	Trucks emit greater amounts of NO _x on an average, per-vehicle basis	State DOT, local/MPO
Fleet equivalent (FE) AADT	Single metric to compare road segments, accounting for AADT and fleet mix	Use AADT and fleet mix in Equation 2 (Section 6.2)
Congestion	Frequent acceleration and stopping can lead to higher per-vehicle emissions	State/local LOS; state DOT or HPMS (number of lanes); congestion maps

4.2 Physical Site Considerations

Table 4-2 provides a summary of physical site characteristics to be considered, and in some cases avoided, in the monitor site selection process. The physical considerations discussed include roadway design, roadside structures, terrain, and meteorology. A complete introduction and discussion of the physical site considerations that need to be accounted for in near-road NO₂ monitoring site placement can be found in Section 7.

Table 4-2. Summary of physical considerations for candidate near-road sites.

Physical Site Component	Impact on Site Selection	Desirable Attributes	Least Desirable Attributes	Potential Information Sources
Roadway design or configuration	Feasibility of monitor placements; affects pollutant transport and dispersion.	At grade with surrounding terrain.	Deep cut-sections/significantly below grade; significantly above grade (fill or bridge); above grade (bridge).	Field reconnaissance; satellite imagery.
Roadside Structures	Feasibility of monitor placement; affects pollutant transport and dispersion.	No barriers present besides low (<2 m in height) safety features such as guardrails.	Presence of sound walls, mature (high and thick) vegetation, obstructive buildings.	Field reconnaissance; satellite imagery.
Terrain	Affects pollutant dispersion, local atmospheric stability.	Flat or gentle terrain, within a valley, or along a road grade.	Along mountain ridges or peaks, hillsides, or other naturally windswept areas.	Field reconnaissance; digital elevation models and vegetation files; satellite imagery.
Meteorology	Affects pollutant transport and dispersion.	Relative downwind locations – winds from road to monitor.	Strongly predominant upwind positions.	Local data; NOAA/NWS; AQS.

4.3 Siting Criteria:

Table 4-3 provides a summary of near-road NO₂ probe placement. A complete discussion of siting requirements and associated recommendations can be found in Section 7.

Table 4-3. Key near-road siting criteria.

Near-Road NO ₂ Siting Criteria (per 40 CFR Part 58, Appendix E)	
Horizontal spacing	Per 40 CFR Part 58 Appendix E: “ <u>As near as practicable</u> to the outside nearest edge of the traffic lanes of the target road segment; but shall not be located at a distance greater than 50 meters, in the horizontal, from the outside nearest edge of the traffic lanes of the target road segment.” This TAD recommends the target distance for near-road NO₂ monitor probes be within 20 meters of the target road whenever possible.
Vertical spacing	Microscale near-road NO ₂ monitoring sites are required to have sampler inlets between 2 and 7 meters above ground level.
Spacing from supporting structures	The probe must be at least 1 meter vertically or horizontally away from any supporting structure, walls, parapets, penthouses, etc., and away from dusty or dirty areas.
Spacing from obstructions	For near-road NO ₂ monitoring stations, the monitor probe shall have an unobstructed air flow, where no obstacles exist at or above the height of the monitor probe, between the monitor probe and the outside nearest edge of the traffic lanes of the target road segment.

4.4 Candidate Site Comparison Matrix

The candidate site comparison matrix presents and organizes all the data recommended to be collected to aid in identifying and prioritizing potential near-road monitoring sites. The individual pieces of information within the matrix are discussed throughout the TAD, from Section 5 through Section 13.

Table 4-4. Suggested data for each candidate site entry in a site comparison matrix.

Site/Segment Parameters	Description of Parameter
Location	Describe if the entry is for a specific point along a road segment or if the entry is representative of a whole road segment. If the entry is for a point, provide a moniker and the latitude and longitude. If for a road segment, identify where the segment boundaries occur (e.g. intersection, mile marker, political boundary, etc.)
Road segment name	Provide given road name and common name (if applicable)
Road type	Type of road (controlled access highway, limited access freeway, arterial, etc.)

Site/Segment Parameters	Description of Parameter
Road segment end points	Denote the location of the road segment end points, including any given names, common names, and the latitude and longitude of each individual end point.
AADT	Provide AADT, source of data, and vintage
HD counts	As available, provide HD counts, source of data, and vintage
FE-AADT	As available, provide FE-AADT, noting HD _m value used. If not the national default value, provide the source of data used to calculate the site-specific value.
Congestion information	Denote value and type (e.g., LOS, , or AADT by lane), data source, and vintage
Roadway design	Denote design type or types present (flat, elevated-fill, cut, etc.). If not flat, identify whether the configuration is a vertical or sloped boundary. Include the height and degree of slope if applicable.
Terrain	Denote the nature of the terrain immediately around the road and also any larger scale terrain features of note
Meteorology	If the entry is for a point, denote the predominate winds and whether the point is relatively upwind or downwind. If the entry is for a whole segment, denote the orientation of the segment to the predominant winds.
Population exposure	Denote any assessment of population exposure and/or likeness to other road segments throughout the CBSA
Roadside structures	Denote the presence of any roadside structures and the height, width, and length
Safety features	Denote any safety features present and the height, width, and length
Infrastructure	Denote existing infrastructure (light poles, billboards, etc.) and potential site proximity (distance)
Interchanges	Denote the presence of any interchanges within or at the end points of the target road segment and potential site proximity (distance), including traffic information if available (AADT, HD counts, etc.)
Surrounding land use	Denote surrounding land use (residential, commercial, etc.). Also note proximity to other large roads, areas of higher relative road density, and/or locations within or near central business districts or urban downtown areas
Nearby sources	If applicable, note nearby NO _x sources (type, tonnage, etc.) and potential site proximity (distance)
Current road construction	Denote any visible or known road construction at the candidate site location or along the target road segment
Future road construction	If known, denote transportation agency plans for any future road construction (including time frame for completion)
Frontage roads	Denote the presence of frontage roads, and whether those roads are included as part of the target road segment.

Site/Segment Parameters	Description of Parameter
Available space – site footprint	Denote any limitations in the space available for a multipollutant monitoring station
Property type	Is it right-of-way (ROW) or private property?
Property owner	Who manages or owns the property under evaluation?
Likelihood of access	Note the level of confidence and any uncertainties regarding the acquisition of access to a particular property
Other details/local knowledge	List any other pertinent details that may have bearing on why a particular candidate site may or may not be selected. This can include information that reflects a state or local agencies' own knowledge of the area or roads under consideration

EPA believes state and local air agency decision-makers can use the data suggested to be collected in the site comparison matrix to adequately characterize selected near-road monitoring site(s) for public dissemination, such as annual monitoring network plans and in AQS, as discussed in Section 14.

Section 5. Recommended Traffic Data and Resources for Use in Identifying Candidate Road Segments for Near-Road NO₂ Monitoring

The key first steps in identifying candidate NO₂ near-road monitoring sites will be to collect and analyze traffic data. Traffic data indicate the anticipated level and type of activity on a given road that can be used to compare anticipated pollutant emissions among multiple road segments in a CBSA. In traffic analysis, a number of terms are used, often interchangeably, to describe a road. The terms can vary by individual transportation agencies (e.g., DOTs and other transportation authorities); these terms are presented, defined, and discussed throughout the TAD as needed.

In general, a road can be defined as an open way for the passage of vehicles, persons, or animals on land. For the purposes of this TAD, the use of the term “road” or “roadway” shall be interpreted to include the entire cross-section or travel corridor (i.e., both directions of the primary travel lanes, plus any ramps, special use lanes, and included frontage roads) of any open ways for passage (over land and water) that may otherwise be labeled as a road, street, collector, arterial, highway, expressway, toll-way, parkway, freeway, or other such commonly used terms. Further, the near-road NO₂ monitoring site selection process suggested within this TAD calls for the evaluation of individual sections or lengths of a road where information about the traffic on the road is known and characterized.

For the purposes of this TAD, the term “road segment” or “roadway segment” is used to define a length of road between two points along the road. Road segments are typically defined by transportation agencies where road segment end-points are located at intersections, highway exits, highway mile markers, geo-political boundaries, or other features where traffic volumes or patterns are likely to change.

This section summarizes the data and sources that are recommended for use in generating a list of candidate road segments for evaluation as potential near-road NO₂ monitoring sites. The purpose of using these recommended data is ultimately to identify locations where the highest motor vehicle emissions leading to peak near-road NO₂ concentrations are likely to occur. In addition to the descriptions in this section, Appendix A provides more detailed information on the variability and some of the uncertainties of these parameters.

5.1 Annual Average Daily Traffic (AADT)

AADT is a measure of the total volume of traffic on a roadway segment (typically in both directions unless specified otherwise) for one year divided by the number of days in the year. This parameter can be used to identify the relative traffic activity and corresponding potential for pollutant emissions experienced along roads. Generally, AADT is representative of the traffic volume along a given length of road or individual road segment. Some traffic data sources may present traffic counts at point locations instead of specifically representing a defined length of road. In these cases, the length and nature of individual road segments and their boundaries may need to be clarified for use in the recommended near-road NO₂ monitoring site selection process as presented in this TAD.

Traffic volume data are typically collected by state DOTs and other local sources, such as MPOs. AADT data sets generally comprise two types of data, recorded and estimated, which are merged to create a full data set. AADT can vary from year to year, depending on actual changes in traffic volumes and based on the timing of when certain road segments are individually measured or estimated, because measurements are not made on every road segment in an urban area each year. However, for this TAD, data users may treat the measured and estimated data equally as long as they are using the latest available data (typically provided annually). In

addition to traditional AADT data, metropolitan area urban travel demand models (TDMs) can also be consulted to estimate future traffic volumes on these segments if needed.

5.2 Sources of AADT Data

State or local traffic volume datasets are created by state DOTs and sometimes MPOs. Often, these data are available on DOT or MPO websites, and likely represent the most up-to-date traffic counts available. In addition to state or local sources, a national source for traffic data is the Highway Performance Monitoring System (HPMS), managed by the U.S. Department of Transportation (U.S. DOT). HPMS (<http://www.fhwa.dot.gov/policy/ohpi/hpms/index.cfm>) AADT data can be downloaded in shapefile format, either as one national file or by region, from the Bureau of Transportation Statistics' National Transportation Atlas Database (http://www.bts.gov/publications/national_transportation_atlas_database/). (Shapefiles contain data within a geospatial format, and thus are displayed as map features.)

One key issue regarding the use of data from HPMS is that the data may be one or more years older than data provided by state and local sources. This potential discrepancy in data source date is because the data in HPMS originates from state DOTs and other local sources, and must be collected, reviewed, and otherwise processed by U.S. DOT before being presented in HPMS. It is thus recommended that state and local air agencies first attempt to obtain and use the most recent data set available from their state DOT or other local sources. In the event that sufficient traffic data are not available from state or local sources, it is then recommended that state and local air agencies use the most recent data available in HPMS for use in the near-road NO₂ monitoring site selection process.

Traffic volume data varies by location, but is most often provided as “counts” for particular road segments. The format of these count data may be available within an interactive interface or may come as downloadable tables, images, or shapefiles. To use shapefiles, state and local air agencies will need to use a mapping software program such as ArcGIS. Regardless of the formatting, state and local air agencies are encouraged to migrate the available data into a spreadsheet or database for use in a comparative process discussed in Section 6.

5.3 Fleet Mix Data

While AADT describes the total volume of traffic on a road, fleet mix data provides specific counts, or percentages of total traffic volume, of different types of vehicles that comprise the total traffic volume. Most commonly, fleet mix data differentiate between light-duty (LD) vehicles (e.g., gasoline fueled) and heavy-duty (HD) vehicles (e.g., diesel fueled). The manner in which fleet data are defined depends on the monitoring methods employed by the state or local transportation agency. In most cases, LD and HD vehicles are differentiated by either weight or length of vehicles on the road. The number of axles can also be used to identify HD from LD vehicles.

Understanding the number or percentage of HD vehicles within the total traffic volume is important because the difference in the amount of nitrogen oxides (NO_x) emitted on a per-vehicle basis between the two vehicle types varies greatly: HD vehicles typically emit much higher amounts of NO_x than LD vehicles on a per-vehicle basis. Since these NO_x emissions include both nitric oxide (NO), which readily converts to NO₂ in the near-road environment in the presence of ozone, and which also can be oxidized to NO₂ through other photochemical processes), and directly-emitted NO₂, these emission differences are important in identifying locations where peak NO₂ concentrations may occur. For all vehicles, NO_x emissions vary by

vehicle type, load, speed, and highway grade. More information on on-road mobile source NO_x emissions, based upon EPA's Motor Vehicle Emission Simulator (MOVES), can be found in Appendix B.

5.4 Sources of Fleet Mix Data

Similar to AADT data, fleet mix data are typically collected by state DOTs or possibly by MPOs. However, fleet mix data are not measured and disseminated as routinely as AADT data. Thus, fleet mix data availability is much more variable from state to state or between individual CBSAs. Further, fleet mix data may not be available for individual road segments, but for larger domains such as counties or urban areas. In cases where fleet mix data are available on a segment by segment basis, the data are often available with related total AADT count data and files, the sources of which are discussed in Section 5.2. Similarly to AADT, state and local air agencies are encouraged to migrate the available fleet mix data into a spreadsheet or database, with AADT data, for use in a comparative process discussed in Section 6.

5.5 Congestion Patterns

Congestion patterns are an important factor in the near-road NO₂ monitoring site selection process because traffic congestion can lead to vehicle operating conditions, particularly stop-and-go traffic, that may increase emissions on a per vehicle basis (as compared to vehicles operating at steady-state highway speeds). Congestion pattern data can be presented in multiple forms. Three example metrics of congestion data that can be used for consideration during the near-road NO₂ monitoring site selection process are discussed next.

5.5.1 Level of Service (LOS)

The first example of congestion pattern data is the level of service (LOS) metric. The LOS system describes the effectiveness of a transportation facility, such as a road segment. LOS is determined for individual road segments by the evaluation of multiple pieces of traffic information, including time-resolved traffic counts, traffic speeds, and the relative frequency of occurrence of congested conditions. The LOS is presented as a qualitative measure, using a letter grading system.

In the LOS grading framework, the grading ranges from A to F, where A describes a road segment with free flowing traffic conditions with speeds at or above the posted limit. On the other end of the spectrum, the letter grade F represents the lowest measure of efficiency for a road segment, which has traffic subjected to forced flows, congestion, and frequent slowing and stopping during peak hours of use. As a result, when considering the candidacy of individual road segments as permanent near-road NO₂ monitoring sites, congestion patterns can be considered in a qualitative manner. In the case of using LOS data to consider congestion patterns, those road segments with higher relative congestion (e.g., a worse letter grade) may be more likely to have relatively higher NO₂ emissions potential per vehicle than otherwise similar road segments with less congestion.

In some cases, LOS may be available for both directions of a particular road segment, and/or may be presented with multiple classifications based on season or time of day. In such cases, the EPA suggests that the worst letter grade LOS be used to represent that particular segment when making comparisons with other road segments. We believe this is an appropriate approach considering that the NO₂ NAAQS is a 1-hour standard, and the objective of the monitoring effort is to characterize the peak NO₂ concentrations that are occurring in the area. The greatest effects

of traffic congestion on peak NO₂ concentrations, represented by LOS, are likely to occur during the worst indicated LOS conditions.

5.5.2 Volume-to-Capacity Ratio

A second metric that can be used as a congestion pattern indicator is the volume-to-capacity () ratio. The ratio compares peak traffic volumes on a road segment with the capacity of the road based on the number of lanes. This calculation typically accounts for the larger size of HD vehicles and focuses on traffic conditions during peak hours of operation.

5.5.3 AADT by Lane

If LOS or data are not available, a third metric to assess possible congestion is a simple calculation to determine the “AADT by lane” for individual road segments. This indicator can be determined by dividing the total AADT by the number of lanes on a road segment. AADT by lane can be used to aid in understanding the potential congestion of a road segment (in the absence of LOS or information) by accounting for how much traffic volume is using a given number of available driving lanes. As such, a larger number of vehicles per lane indicates a greater potential for traffic congestion. However, AADT by lane is not based on the multiple metrics that LOS and are based upon, and should be viewed only as a rough surrogate to what these data might represent for a given road segment. Thus, AADT by lane is suggested for use only if LOS or data are not available. The method of calculating AADT by lane is discussed in Section 5.6.

5.6 Sources of Congestion Pattern Data

LOS and data, if available, are determined and disseminated by state DOTs or MPOs. However, these metrics are not as common as AADT or fleet mix data and thus may not be

available for all CBSAs where near-road NO₂ monitoring is required. If these data are not available from state DOTs or MPOs, the use of AADT by lane or some other similar congestion pattern metric is recommended as a surrogate. To determine AADT by lane, knowledge of the number of lanes on a road segment, along with the total number of vehicles on that segment, is required. If those data are known, the AADT by lane can be estimated by using **Equation 1**.

$$\text{AADT by lane} = \text{AADT} / \text{Number of Lanes} \quad (1)$$

where AADT is the actual total traffic volume on the road segment, and the number of lanes is the total number of lanes, in both directions, on that road segment.

Section 6. Creating an Initial List of Candidate Road Segments Using Traffic Data

The site selection process for required near-road NO₂ monitors, per 40 CFR Part 58 Appendix D, includes the ranking of road segments in a CBSA by AADT, followed by the consideration of five other factors, which include fleet mix and congestion patterns, in the site selection process. The other three factors (roadway design, terrain, and meteorology) are discussed in Section 7.

This section presents a process by which state and local air agencies may use available traffic data to create an initial list of candidate road segments for further evaluation as potential near-road monitoring sites. In this process, the EPA believes that a state or local agency will be satisfying a portion of the minimum monitoring requirements by ranking road segments using AADT, and by considering both fleet mix and congestion patterns as factors in the ranking process. The purpose of this process is to identify road segments, ranked by priority, where peak NO₂ concentrations attributable to on-road mobile sources are most likely to occur in a CBSA on a routine basis.

Figure 6-1 presents a visualization of the traffic data evaluation process, reflecting the four steps presented in this section as a flowchart, providing alternate evaluation paths dependent on what traffic data may or may not be available. Subsequent to creating a prioritized list of road segments for further evaluation, state and local air agencies will be in a position to consider the three remaining factors required of them in CFR, which are roadway design, terrain, and meteorology, plus the additional case-by-case factors that will impact where near-road NO₂ monitoring sites might go, while working with partners and stakeholders (e.g., EPA Regions, transportation agencies).

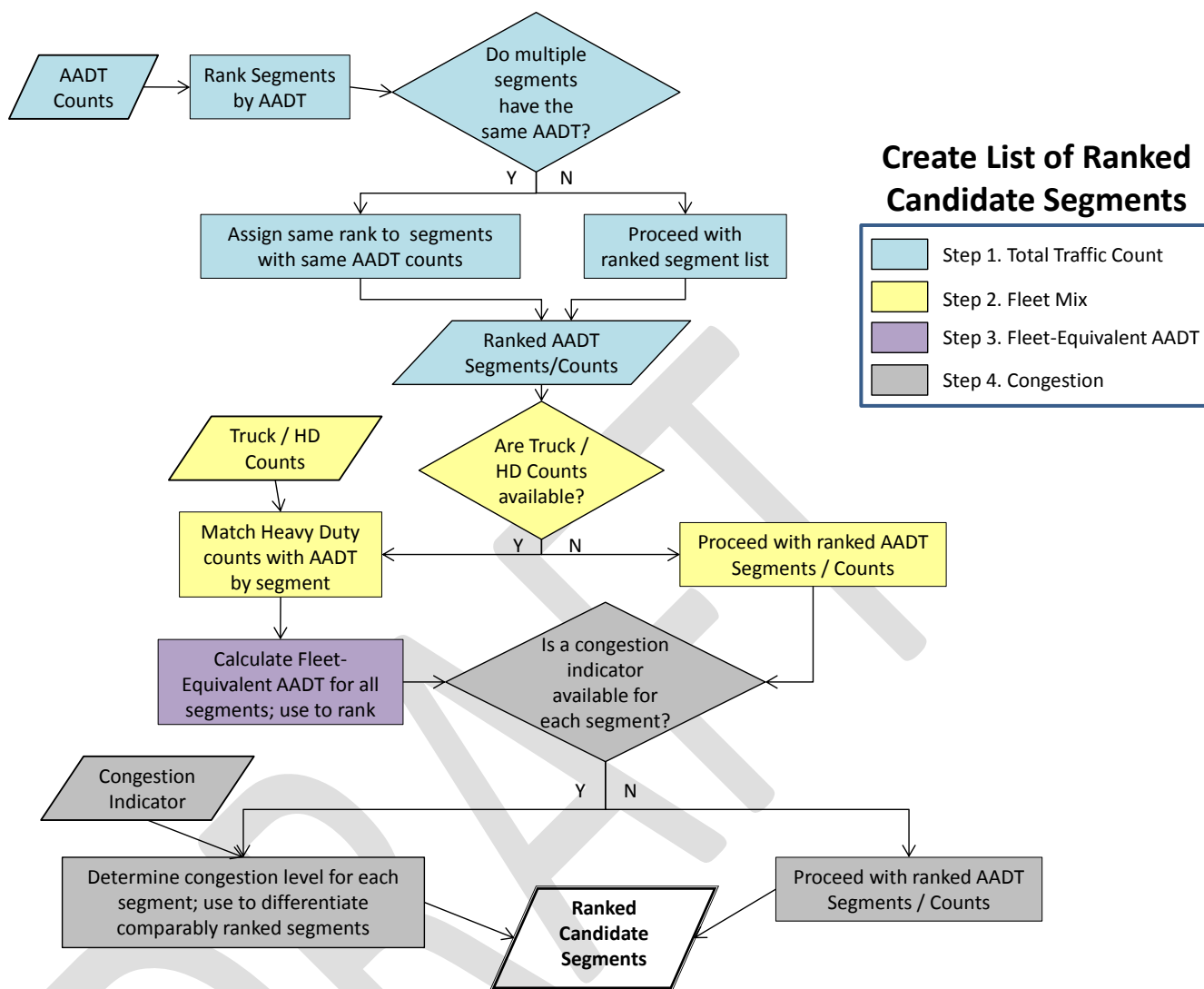


Figure 6-1. Candidate Road Segment Ranking Process. This flowchart presents the traffic data evaluation process to provide a prioritized list of candidate road segments (accounting for traffic volume [AADT], fleet mix, and congestion) for further evaluation as potential near-road NO₂ monitoring stations.

6.1 Using AADT to Initially Rank Road Segments

The first step in the traffic data evaluation process is to satisfy the requirement in 40 CFR Part 58, Appendix D, section 4.3, to rank road segments in a CBSA based on the total traffic volume, represented by AADT. The intent of this first step is to begin to focus the evaluation

process on road segments that are more likely to have higher potential for NO_x emissions due to their higher volumes of traffic.

STEP 1 – Generate a list of road segments in the CBSA in descending order, where the segment with the highest AADT is ranked first. This list should include at a minimum the road segment ID, location information, road information, and AADT value. In situations where two or more road segments have the same AADT value, those segments should be assigned the same numerical ranking.

Table 6-1 is an example of road segments ranked by AADT for the Tampa, Florida CBSA using 2009 data from the Florida DOT. It lists the roadway name in the first column, the physical end points of the road segment in columns two and three, AADT in the fourth, and the segment rank in the final column. Although all road segments were ranked in the development of this example, for illustrative purposes, only the top 23 segments are listed here. State and local agencies should rank those segments for which data are available for each CBSA in this initial step.

Table 6-1. This table illustrates the ranking of road segments by AADT, as described in Step 1, for the Tampa, Florida, CBSA, using 2009 traffic data available from Florida DOT. Note that all available road segments within the CBSA were ranked; however, to conserve space within this document, only the top 23 segments are shown.

Roadway	From	To	AADT	AADT Rank
I-275	Bridge No-100128	Bridge No-100110	192,000	1
I-275	CR587/WESTSHORE BLVD	Bridge No-100120	176,500	2
I-275	S600/U92/DALE MABRY	Bridge No-100128	170,500	3
I-275	Bridge No-100138	10320000/10320001	169,000	4
I-275	Bridge No-100110	Bridge No-100138	169,000	4
I-275	SLIGH AVE	Bridge No-100219	167,000	5
I-4	10320000/10320001	Bridge No-100658	164,000	6
I-275	Bridge No-100120	S600/U92/DALE MABRY	163,000	7
I-275	FLORIBRASKA AVE	Bridge No-100203	160,500	8
SR-60	SR 616	SR 93 / I-275	158,000	9
I-275	SR 600 / HILLS AVE	SLIGH AVE	156,500	10
I-275	Bridge No-100203	SR 600 / HILLS AVE	153,500	11
I-275	SR 580 / BUSCH BLVD	Bridge No-100231	151,500	12
I-275	Bridge No-100219	SR 580 / BUSCH BLVD	151,500	12
I-4	Bridge No-100658	US 41/SR 599/50TH ST	151,000	13
I-275	EAST END BR 150107	Bridge No-100115	147,000	14
I-275	4TH ST N	END BRIDGE 150107	147,000	14
I-275	Columbus Dr	FLORIBRASKA AVE	147,000	14
I-4	US 301 / SR 43	I-75/SR 93A	136,500	15
I-4	I-75/SR 93A	Mango Rd	136,500	15
I-4	Bridge No-100115	CR587/WESTSHORE BLVD	135,500	16
I-275	SR 688/Ulmerton Rd	4TH ST N	130,000	17
I-4	Mango Rd	MCINTOSH RD	127,000	18
I-275	GANDY BLVD/SR 694	ROOSEVELT BL/SR 686	123,000	19
I-275	38TH AVE N	54TH AVE N	123,000	19
I-275	ROOSEVELT BL/SR 686	N/A	123,000	19
I-275	54TH AVE N	GANDY BLVD/SR 694	123,000	19
I-275	22ND AVE N	38TH AVE N	123,000	19
I-4	SR 574/ML KING BLVD	ORIENT RD	122,000	20
I-4	US 41/SR 599/50TH ST	SR 574/ML KING BLVD	121,000	21
I-4	MCINTOSH RD	Bridge No-100599	117,932	22
I-4	ORIENT RD	US 301 / SR 43	113,000	23
I-75	GIBSONTOWN DR	SR 43 / US 301	111,500	24
I-4	Bridge No-100599	S566/THONOTOSASSA RD	110,000	25

6.2 Combining Fleet Mix Data and AADT Data to Rank Road Segments

As discussed in Section 5.3, the fleet mix metric accounts for the amount of HD vehicles on a roadway, or the ratio of HD vehicles to LD vehicles on a road. Fleet mix is an important factor because of the higher amount of NO_x emitted by HD vehicles per vehicle. Therefore, accounting for fleet mix in the near-road NO₂ monitoring site selection process more accurately focuses the search on road segments where potential on-road emissions may more consistently lead to peak NO₂ concentrations in the near-road environment.

If fleet mix data are available on a segment by segment basis, or some other categorization up to a county by county characterization, proceed with Step 2. If you do not have fleet mix data that is differentiated within a CBSA, skip ahead to Step 4 in Section 6.3.

STEP 2 – Link the total volume of heavy-duty vehicles to the AADT list generated in Step 1, matching the two data sets by segment. If another form of fleet mix distribution is available (such as county level data), assign the available values or percentages to all the corresponding road segments.

Table 6-2 has been updated from Table 6-1 and contains a new column for HD vehicles for each of the initial road segments found in Step 1 and presented in Table 6-1. For illustration purposes, the rows were re-ranked based on HD vehicle counts. In this example, the twenty-eighth-ranked AADT road segment had the highest HD counts. The top-ranked total AADT road segment from Step 1 has the twenty-seventh-highest rank based solely on HD counts. Again, this list is arbitrarily cut off to conserve space in this document; all segments with available data should be included in this step.

Table 6-2. This table has been updated from Table 6-1 to include fleet mix data as described in Step 2. It illustrates the ranking of road segments based on fleet mix for the Tampa, Florida, CBSA, using 2009 traffic data available from Florida DOT. For illustrative purposes, this table was re-ranked by heavy duty vehicle AADT.

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank
I-4	Bridge No-100607	HILLS/POLK CO LINE	105,000	28	15,719	1
I-4	Bridge No-100605	Bridge No-100607	103,000	29	15,388	2
I-4	Bridge No-100599	S566/THONOTOSASSA RD	110,000	25	15,279	3
I-4	S566/THONOTOSASSA RD	Bridge No-100605	98,000	30	14,396	4
I-4	US 301 / SR 43	I-75/SR 93A	136,500	15	14,073	5
I-4	I-75/SR 93A	Mango Rd	136,500	15	13,172	6
I-75	PASCO CO LINE	US 98 / CORTEZ BLVD	40,500	102	12,859	7
I-75	N/A	HERNANDO CO LINE	40,500	102	12,859	7
I-4	MCINTOSH RD	Bridge No-100599	117,932	22	12,595	8
I-75	GIBSONTON DR	SR 43 / US 301	111,500	24	12,577	9
I-4	10320000/10320001	Bridge No-100658	164,000	6	12,251	10
I-4	Bridge No-100658	US 41/SR 599/50TH ST	151,000	13	12,050	11
I-75	HILLSBOROUGH CO LINE	CR 54	68,500	49	11,542	12
I-4	SR 574/ML KING BLVD	ORIENT RD	122,000	20	11,236	13
I-75	SR 582 / FOWLER AVE	CR 582A/FLETCHER AVE	108,500	26	10,579	14
I-75	SR 400 / I-4	SR 582 / FOWLER AVE	108,500	26	10,579	14
I-75	SR 574/M L KING BLVD	SR 400 / I-4	108,500	26	10,579	14
I-75	CR 582A/FLETCHER AVE	C581/BRUCE B.DOWNS B	90,500	34	10,498	15
I-4	Mango Rd	MCINTOSH RD	127,000	18	10,465	16
I-75	SR 674/E COLLEGE AVE	Bridge No-100363	67,000	51	10,285	17
I-75	Bridge No-100363	GIBSONTON DR	89,000	35	10,217	18
I-75	SB I-275	NB I-275	60,500	60	9,462	19

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank
I-75	HILLSBOROUGH COUNTY	SB I-275	60,500	60	9,462	19
I-75	C581/BRUCE B.DOWNS B	PASCO CO LINE	60,500	60	9,462	19
I-75	SR 52	N/A	40,000	103	9,304	20
I-275	FLORIBRASKA AVE	Bridge No-100203	160,500	8	9,229	21
I-275	EAST END BR 150107	Bridge No-100115	147,000	14	9,026	22
I-275	4TH ST N	END BRIDGE 150107	147,000	14	9,026	22
I-4	US 41/SR 599/50TH ST	SR 574/ML KING BLVD	121,000	21	9,014	23
I-75	MANATEE CO LINE	SR 674/E COLLEGE AVE	55,500	68	8,919	24
I-275	S600/U92/DALE MABRY	Bridge No-100128	170,500	3	8,713	25
I-275	SLIGH AVE	Bridge No-100219	167,000	5	8,684	26
I-275	Bridge No-100128	Bridge No-100110	192,000	1	8,467	27
RTE-41	OLD COLUMBUS DR(UNS)	N 48TH ST	107,500	27	8,342	28
I-275	Bridge No-100138	10320000/10320001	169,000	4	8,298	29
I-275	Bridge No-100110	Bridge No-100138	169,000	4	8,298	29
I-275	SR 688/Ulmerton Rd	4TH ST N	130,000	17	8,281	30
I-4	ORIENT RD	US 301 / SR 43	113,000	23	8,215	31
I-275	Bridge No-100120	S600/U92/DALE MABRY	163,000	7	7,824	32
I-275	Bridge No-100203	SR 600 / HILLS AVE	153,500	11	7,736	33
I-275	SR 600 / HILLS AVE	SLIGH AVE	156,500	10	7,669	34
I-75	N/A	SR 60/ADAMO DR	92,500	33	7,530	35
I-75	SR 43 / US 301	N/A	92,500	33	7,530	35
I-75	SR 60/ADAMO DR	SR 574/M L KING BLVD	92,500	33	7,530	35
I-275	CR587/WESTSHORE BLVD	Bridge No-100120	176,500	2	7,413	36

Although comparing **Table 6-1** to Table 6-2 is informative, it is not easy to simultaneously compare the ranked lists between both AADT and fleet mix. In order to more easily compare one road segment to another, particularly when those road segments have a varied amount of both total traffic volume and HD vehicle volume, the EPA recommends the use of a unique metric that accounts for both total traffic volume and fleet mix for comparison purposes, called Fleet-Equivalent (FE) AADT.

With the FE-AADT metric, roads can be re-ranked in an order that reflects both AADT and fleet mix (if information on the amount of heavy-duty vehicles that are present on each individual road segment are available) within one numerical value. Re-ranking by FE-AADT presents a prioritized list of road segments that are more likely representative of estimated or potential NO_x emissions than either AADT or fleet mix alone. The determination of FE-AADT per segment depends on three factors: (1) total traffic volume, presented as AADT counts, (2) fleet mix, presented as HD vehicle counts, and (3) the heavy-duty to light-duty vehicle NO_x emission ratio. **Equation 2** can be used to determine a Fleet-Equivalent AADT value for each road segment:

$$\text{Fleet-Equivalent (FE) AADT} = (\text{AADT} - \text{HD}_c) + (\text{HD}_m * \text{HD}_c) \quad (2)$$

where AADT is the total traffic volume count for a particular road segment, HD_c is the total number of heavy-duty vehicles for a particular road segment, and HD_m is a multiplier that represents the heavy-duty to light-duty NO_x emission ratio for a particular road segment.

The HD_m multiplier can be obtained several ways. One option is to determine HD_m from national average motor vehicle emission factors, resulting in the same HD_m value being used for all road segments being characterized in a CBSA as described below. Using this option results

in a value for HD_m , which should be suitable for many situations. Alternatively, the HD_m value can be derived from local vehicle speed and/or emissions estimates for in a given CBSA that can provide a specific HD_m value across the CBSA or for individual road segments.

For this TAD, we have used the national default approach. Based on information derived from EPA's Motor Vehicle Emission Simulator (MOVES), the EPA suggests that the national default for HD_m be 10. This approach and HD_m value is applied and used in all examples where FE-AADT is calculated in this TAD. In using a national default where HD_m equals 10, the assumption is made that the NO_x emissions from one HD vehicle are equivalent to the NO_x emissions from 10 LD vehicles operating on the same road segment and under the same environmental and relative operating conditions. When using the national default HD_m of 10, Equation 2 can be simplified to **Equation 3**.

$$\text{FE-AADT} = (\text{AADT} - \text{HD}_c) + (10 * \text{HD}_c) \quad (3)$$

The details on the rationale for the national default HD_m value of 10, as well as guidance for local municipalities to calculate their own HD_m value, are included in Appendix B. If air agencies have appropriate on-road vehicle fleet mix and speed characterizations for roads in their jurisdictions, they may choose to calculate their own ratio, which may be more accurate for their particular road segment(s) of interest. For example, state and local agencies may choose to calculate a local HD_m value or values based on information for a specific road segment (e.g., a given segment experiences higher congestion with lower average vehicle speeds or may have a higher percentage of older diesel trucks or buses). Agencies may also consider calculating a local HD_m value for a particular season, such as when air quality violations occur in only one season at an existing area-wide NO₂ monitor.

STEP 3 - Calculate the Fleet-Equivalent AADT values for each road segment using Equation 2 (if using locally derived HD to LD NO_x emission ratios) or Equation 3 (if using the national default HD to LD ratio of 10). Re-prioritize the candidate site list based upon FE-AADT, where the road segment with the highest FE-AADT value is ranked first and subsequent road segments are presented in descending order.

Table 6-3 has been updated from Table 6-2 with an additional column to reflect FE-AADT.

The road segments have been re-ranked based on the FE-AADT value. In this example, the sixth-ranked AADT (tenth-ranked HD) segment has moved to the first-ranked position. Two notable changes are that the first-ranked AADT (twenty-seventh-ranked HD) segment is only moved down to second, and that the first-ranked HD segment (twenty-eighth-ranked AADT) is now ranked eighth. This table illustrates that accounting for higher per-vehicle NO_x emission rates for HD vehicles using the heavy-duty to light-duty NO_x emissions ratio (described in Equations 2 and 3) has a significant effect on the ranking of the road segments for further consideration as candidate near-road NO₂ monitoring sites with the magnitude of this effect dependent on the HD_m value(s) chosen.

Table 6-3. This table has been updated from Table 6-2 to reflect the calculation of Fleet Equivalent (FE) AADT as described in Step 3. The listed road segments from the Tampa CBSA are ranked by FE-AADT, which was calculated by using 2009 traffic data available from Florida DOT.

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank	FE-AADT	FE-AADT Rank
I-4	10320000/10320001	Bridge No-100658	164,000	6	12,251	10	274,259	1
I-275	Bridge No-100128	Bridge No-100110	192,000	1	8,467	27	268,203	2
I-4	US 301 / SR 43	I-75/SR 93A	136,500	15	14,073	5	263,157	3
I-4	Bridge No-100658	US 41/SR 599/50TH ST	151,000	13	12,050	11	259,450	4
I-4	I-75/SR 93A	Mango Rd	136,500	15	13,172	6	255,048	5
I-275	S600/U92/DALE MABRY	Bridge No-100128	170,500	3	8,713	25	248,917	6
I-4	Bridge No-100599	S566/THONOTOSASSA RD	110,000	25	15,279	3	247,511	7
I-4	Bridge No-100607	HILLS/POLK CO LINE	105,000	28	15,719	1	246,471	8
I-275	SLIGH AVE	Bridge No-100219	167,000	5	8,684	26	245,156	9
I-275	Bridge No-100138	10320000/10320001	169,000	4	8,298	29	243,682	10
I-275	Bridge No-100110	Bridge No-100138	169,000	4	8,298	29	243,682	10
I-275	FLORIBRASKA AVE	Bridge No-100203	160,500	8	9,229	21	243,561	11
I-275	CR587/WESTSHORE BLVD	Bridge No-100120	176,500	2	7,413	36	243,217	12
I-4	Bridge No-100605	Bridge No-100607	103,000	29	15,388	2	241,492	13
I-275	Bridge No-100120	S600/U92/DALE MABRY	163,000	7	7,824	32	233,416	14
I-4	MCINTOSH RD	Bridge No-100599	117,932	22	12,595	8	231,287	15
I-275	EAST END BR 150107	Bridge No-100115	147,000	14	9,026	22	228,234	16
I-275	4TH ST N	END BRIDGE 150107	147,000	14	9,026	22	228,234	16

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank	FE-AADT	FE-AADT Rank
I-4	S566/THONOTOSASS A RD	Bridge No-100605	98,000	30	14,396	4	227,564	17
I-275	SR 600 / HILLS AVE	SLIGH AVE	156,500	10	7,669	34	225,521	18
I-75	GIBSONTON DR	SR 43 / US 301	111,500	24	12,577	9	224,693	19
I-4	SR 574/ML KING BLVD	ORIENT RD	122,000	20	11,236	13	223,124	20
I-275	Bridge No-100203	SR 600 / HILLS AVE	153,500	11	7,736	33	223,124	20
I-4	Mango Rd	MCINTOSH RD	127,000	18	10,465	16	221,185	21
I-275	SR 580 / BUSCH BLVD	Bridge No-100231	151,500	12	7,105	39	215,445	22
I-275	Bridge No-100219	SR 580 / BUSCH BLVD	151,500	12	7,105	39	215,445	22
SR-60	SR 616	SR 93 / I-275	158,000	9	5,941	42	211,469	23
I-275	Columbus Dr	FLORIBRASKA AVE	147,000	14	7,159	38	211,431	24
I-275	SR 688/Ulmerton Rd	4TH ST N	130,000	17	8,281	30	204,529	25
I-75	SR 582 / FOWLER AVE	CR 582A/FLETCHER AVE	108,500	26	10,579	14	203,711	26
I-75	SR 400 / I-4	SR 582 / FOWLER AVE	108,500	26	10,579	14	203,711	26
I-75	SR 574/M L KING BLVD	SR 400 / I-4	108,500	26	10,579	14	203,711	26
I-4	US 41/SR 599/50TH ST	SR 574/ML KING BLVD	121,000	21	9,014	23	202,126	27
I-4	Bridge No-100115	CR587/WESTSHORE BLVD	135,500	16	7,371	37	201,839	28
I-4	ORIENT RD	US 301 / SR 43	113,000	23	8,215	31	186,935	29
I-75	CR 582A/FLETCHER AVE	C581/BRUCE B.DOWNS B	90,500	34	10,498	15	184,982	30

6.3 Using Congestion Pattern Indicators to Supplement Road Segment Rankings

The EPA does not recommend that any of the congestion indicators be used in a quantitative manner to further re-rank or re-prioritize the whole list of candidate road segments resulting from Step 3 (or Step 1 if fleet mix data are not available). This recommendation is due to the relatively higher potential for incomplete data and overall uncertainties. Instead, such data are believed to be more useful as a qualitative measure by which one road segment might be selected over other relatively similar candidate road segments in the overall selection process. In such a situation, it is recommended that when using LOS data, a higher priority should be placed on road segments with a lower or worse LOS, where A is the highest or best LOS grade and F is the lowest or worst LOS grade. If LOS is not available, but either ratios or “AADT by lane” is available for use, a higher priority should be placed on road segments with higher or AADT per lane values.

STEP 4 – Add the congestion indicator (LOS, , or AADT by lane value from Equation 2, if available) to the candidate site list. These data will be used in the overall evaluation process, and can be used as a qualitative metric to aid in selecting one candidate road segment over other similarly ranked candidates.

Table 6-4 has been updated from Table 6-3 with a column displaying congestion information in the form of LOS letter grades. The LOS for the example was gathered from five different data sources. Table 6-4 shows that a majority of the higher ranked FE-AADT segments have an LOS value of F, which indicates that these segments are also some of the most congested. As a result, there is little discernible difference among the higher FE-AADT ranked candidate sites for the Tampa CBSA example based on the congestion indicators.

Table 6-4. This table has been updated from Table 6-3; it now has congestion pattern information per segment from the Tampa, Florida, CBSA added in the last column. In this example, LOS data were available from Florida DOT. The segments are still ranked by FE-AADT. Note that LOS data that were made available span several years; however, we have treated the data equally in this example.

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank	FE-AADT	FE-AADT Rank	LOS
I-4	10320000/10320001	Bridge No-100658	164,000	6	12,251	10	274,259	1	F (2005)
I-275	Bridge No-100128	Bridge No-100110	192,000	1	8,467	27	268,203	2	F (2005)
I-4	US 301 / SR 43	I-75/SR 93A	136,500	15	14,073	5	263,157	3	F (2008)
I-4	Bridge No-100658	US 41/SR 599/50TH ST	151,000	13	12,050	11	259,450	4	F (2005)
I-4	I-75/SR 93A	Mango Rd	136,500	15	13,172	6	255,048	5	F (2008)
I-275	S600/U92/DALE MABRY	Bridge No-100128	170,500	3	8,713	25	248,917	6	F (2005)
I-4	Bridge No-100599	S566/THONOTOSASSA RD	110,000	25	15,279	3	247,511	7	F (2008)
I-4	Bridge No-100607	HILLS/POLK CO LINE	105,000	28	15,719	1	246,471	8	F (2008)
I-275	SLIGH AVE	Bridge No-100219	167,000	5	8,684	26	245,156	9	F (2005)
I-275	Bridge No-100138	10320000/10320001	169,000	4	8,298	29	243,682	10	F (2005)
I-275	Bridge No-100110	Bridge No-100138	169,000	4	8,298	29	243,682	10	D (2005)
I-275	FLORIBRASKA AVE	Bridge No-100203	160,500	8	9,229	21	243,561	11	F (2005)
I-275	CR587/WESTSHORE BLVD	Bridge No-100120	176,500	2	7,413	36	243,217	12	F (2005)
I-4	Bridge No-100605	Bridge No-100607	103,000	29	15,388	2	241,492	13	F (2008)
I-275	Bridge No-100120	S600/U92/DALE MABRY	163,000	7	7,824	32	233,416	14	F (2005)
I-4	MCINTOSH RD	Bridge No-100599	117,932	22	12,595	8	231,287	15	F (2008)
I-275	EAST END BR 150107	Bridge No-100115	147,000	14	9,026	22	228,234	16	E (2005)
I-275	4TH ST N	END BRIDGE 150107	147,000	14	9,026	22	228,234	16	D (2008)
I-4	S566/THONOTOSASSA RD	Bridge No-100605	98,000	30	14,396	4	227,564	17	F (2008)
I-275	SR 600 / HILLS AVE	SLIGH AVE	156,500	10	7,669	34	225,521	18	F (2005)

Roadway	From	To	AADT	AADT Rank	Heavy Duty Vehicle AADT	Heavy Duty Vehicle AADT Rank	FE-AADT	FE-AADT Rank	LOS
I-75	GIBSONTON DR	SR 43 / US 301	111,500	24	12,577	9	224,693	19	C (2008)
I-4	SR 574/ML KING BLVD	ORIENT RD	122,000	20	11,236	13	223,124	20	E (2008)
I-275	Bridge No-100203	SR 600 / HILLS AVE	153,500	11	7,736	33	223,124	20	F (2005)
I-4	Mango Rd	MCINTOSH RD	127,000	18	10,465	16	221,185	21	F (2008)
I-275	SR 580 / BUSCH BLVD	Bridge No-100231	151,500	12	7,105	39	215,445	22	E (2005)
I-275	Bridge No-100219	SR 580 / BUSCH BLVD	151,500	12	7,105	39	215,445	22	F (2005)
SR-60	SR 616	SR 93 / I-275	158,000	9	5,941	42	211,469	23	C (2005)
I-275	Columbus Dr	FLORIBRASKA AVE	147,000	14	7,159	38	211,431	24	F (2005)
I-275	SR 688/Ulmerton Rd	4TH ST N	130,000	17	8,281	30	204,529	25	D (2007)
I-75	SR 582 / FOWLER AVE	CR 582A/FLETCHER AVE	108,500	26	10,579	14	203,711	26	F (2008)
I-75	SR 400 / I-4	SR 582 / FOWLER AVE	108,500	26	10,579	14	203,711	26	F (2008)
I-75	SR 574/M L KING BLVD	SR 400 / I-4	108,500	26	10,579	14	203,711	26	F (2008)
I-4	US 41/SR 599/50TH ST	SR 574/ML KING BLVD	121,000	21	9,014	23	202,126	27	F (2008)
I-275	Bridge No-100115	CR587/WESTSHORE BLVD	135,500	16	7,371	37	201,839	28	F (2005)
I-4	ORIENT RD	US 301 / SR 43	113,000	23	8,215	31	186,935	29	E (2008)
I-75	CR 582A/FLETCHER AVE	C581/BRUCE B.DOWNS B	90,500	34	10,498	15	184,982	30	F (2008)
I-275	GANDY BLVD/SR 694	ROOSEVELT BL/SR 686	123,000	19	6,876	41	184,884	31	A, B, or C (2007)

6.4 Road Segment Ranking Process

Completion of as many of the steps in Sections 6.1 through 6.3 as possible (based on available traffic data) results in a prioritized list of candidate road segments in which the highest-ranked road segments are expected to be the locations where traffic volume, fleet mix, and congestion patterns combine to contribute to a greater potential for, and/or more frequent occurrences of, peak NO₂ concentrations in the near-road environment. **Table 6-5** summarizes the parameters described in this section, along with their recommended sources and/or methods of calculation, needed to produce the list of prioritized candidate road segments. This list is recommended to guide subsequent evaluation processes (described in the following sections of this document) to determine where permanent near-road NO₂ monitoring stations will be installed.

Table 6-5. Summary of the traffic-related metrics for candidate site consideration.

Component	Rationale	Potential Sources
AADT	Focus on locations with high traffic volumes	State DOT, local/MPO, or US DOT's HPMS
Fleet mix	Trucks emit greater amounts of NO _x on an average, per-vehicle basis	State DOT, local/MPO
Fleet equivalent (FE) AADT	Single metric to compare road segments, accounting for AADT and fleet mix	Use AADT and fleet mix in Equation 2 (Section 6.2)
Congestion	Frequent acceleration and stopping can lead to higher per-vehicle emissions	State/local LOS; state DOT or HPMS (number of lanes); congestion maps

Section 7. Physical Considerations for Candidate Near-Road Monitoring Sites

Once an initial list of candidate sites is created, whether through a process such as that described in Section 6, through use of methods such as monitoring or modeling as described in Sections 9 and 10, or via other approaches, select segments must be further evaluated to determine adequacy for a near-road monitoring station. Specifically, candidate road segments need to be inspected to account for roadway design, terrain, and meteorological factors (covered in this section), and also for safety and logistical considerations, and possibly for population exposure potential (covered in subsequent sections). This section provides a review of the three, non-traffic related data considerations listed in the CFR: roadway design (including related roadside structures), terrain, and meteorology.

Table 7-1 provides an overview of the physical characteristics that need to be considered in evaluating candidate sites, including positive and negative attributes. Additional details on these characteristics are included in the sections that follow.

Table 7-1. Summary of physical considerations for candidate near-road sites.

Physical Site Component	Impact on Site Selection	Desirable Attributes	Least Desirable Attributes	Potential Information Sources
Roadway design or configuration	Feasibility of monitor placements; affects pollutant transport and dispersion.	At grade with surrounding terrain.	Deep cut-sections/significantly below grade; significantly above grade (fill or bridge); above grade (bridge).	Field reconnaissance; satellite imagery.
Roadside Structures	Feasibility of monitor placement; affects pollutant transport and dispersion.	No barriers present besides low (<2 m in height) safety features such as guardrails.	Presence of sound walls, mature (high and thick) vegetation, obstructive buildings.	Field reconnaissance; satellite imagery.
Terrain	Affects pollutant dispersion, local atmospheric stability.	Flat or gentle terrain, within a valley, or along road grade.	Along mountain ridges or peaks, hillsides, or other naturally windswept areas.	Field reconnaissance; digital elevation models and vegetation files; satellite imagery.
Meteorology	Affects pollutant transport and dispersion.	Relative downwind locations – winds from road to monitor.	Strongly predominant upwind positions.	Local data; NOAA/NWS; AQS.

7.1 Roadway Design

The design (or configuration) of a roadway can influence the amount of emissions generated from motor vehicles and the transport and dispersion of those emissions along and/or away from the road. Roadway design includes features of the road itself, such as the slope or grade of a roadbed (which is often a reflection of local terrain or topography), the presence of access ramps, intersections, interchanges, or other such locations where traffic may merge or disperse, and a roadbed's position relative to the immediate surrounding terrain. In particular, road grades create an increased load on vehicles ascending a grade, leading to increased exhaust emissions as

the vehicle does more work to continue its forward motion. In addition, the presence of ramps, intersections, and lane merge locations can lead to increased but localized emissions due to the propensity for acceleration and potential for stop-and-go vehicle operations resulting from traffic congestion.

The relative position of a road to the immediate terrain around the roadway can have a significant influence on pollutant transport and dispersion along and/or away from the source road. The three general types of roadway design discussed here are at-grade, cut-section, and elevated roads.

7.1.1 At-Grade Roads

At-grade roads are those where the roadway surface (on which the vehicles are travelling) is generally at the same elevation as the surrounding terrain. In any particular wind condition (e.g., winds parallel or normal to the road) at-grade roads will experience the least amount of influence on pollutant dispersion among all roadway design types, not accounting for other structures or obstacles (discussed in Section 7.2) that can exist in the near-road environment.



7.1.2 Below-Grade or Cut-Section Roads

Cut-section roads are those where the roadway surface elevation is below the surrounding terrain. A cut-section road can have vertical or sloped walls, of which the walls can be natural or man-made. Under perpendicular wind conditions (normal to the road), cut-section roads tend to

cause lofting of the traffic plume as wind flows through, up, and out of the depressed road canyon. With wind conditions parallel or near-parallel to the source road, on-road emissions may be funneled downwind for some distance with emissions contained, akin to what



happens in an urban street canyon. Channeling of winds may also occur within the cut section as a result of turbulence and wind flow generated from the vehicles operating on the road.

7.1.3 Above-Grade or Elevated Roads

Elevated roadways are those where the roadway surface is higher, in the vertical, than the surrounding topography. Elevated roads can be elevated primarily in two ways: (1) roads built



on an earthen berm or other solid material, where such earth or material may be referred to as “fill,” with no open space underneath the road surface for airflow, and (2) roads built on pilings or supports with open space underneath, where air may

flow both above and beneath the road surface, such as a bridge.

- Elevated roads over solid fill material can have similar dispersion patterns as at-grade roads with winds normal to the road, since shear forces can draw the traffic plume back

to the surface, downwind of a sloped fill section. However, some fill configurations (e.g., those with vertical or sharply sloped walls) can cause the traffic plume to loft above the ground immediately adjacent to the vertical or sharply sloped wall (where eddy formation immediately downwind of the roadbed is occurring), with the core of the emission plume impacting the ground further downwind from the vertical or sharply sloped wall.

- Elevated roads which are open underneath can have enhanced dispersion of on-road emissions with all wind directions. In these cases, emissions are more readily dispersed due to the increased dilution air (moving above and below the roadbed) and from the turbulence caused by the elevated road structure itself. Because of this, ground-level concentrations downwind of the elevated roadbed may not be as high as concentrations found at-grade or with similar roads which are elevated on fill.



7.1.4 Relative Desirability in Roadway Designs

The general understanding of the effect of roadway design on emissions dispersion as described above has been derived through review of near-road field studies and the use of wind tunnel facilities. For example, **Figure 7-1** shows an example from a wind tunnel study comparing roadway configurations and changes in near-road air pollutant concentrations (along a path normal to the source roadway) that illustrates these effects. These results can be translated

to a qualitative hierarchy of relative desirability in roadway designs for consideration in the near-road site selection process.

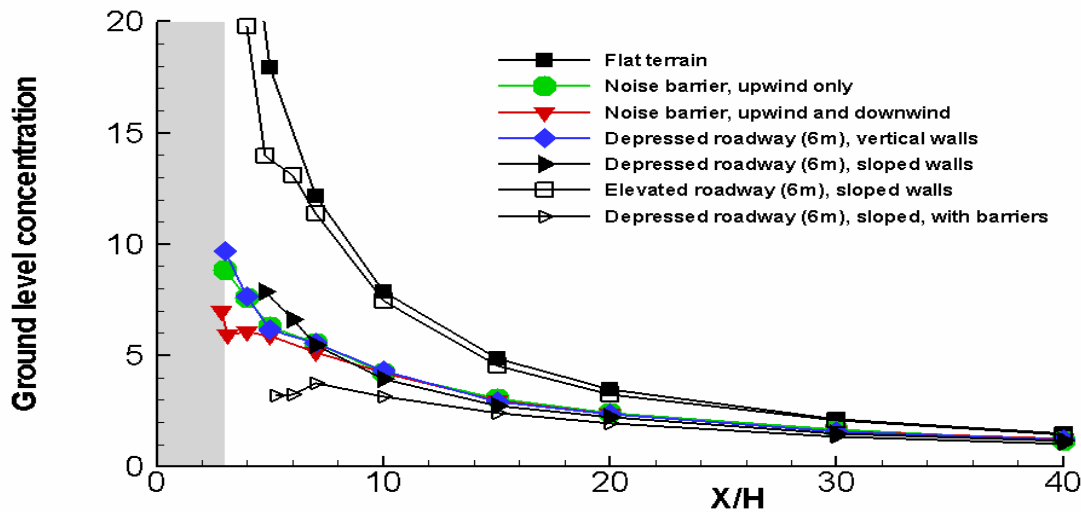


Figure 7-1. Wind tunnel study results comparing downwind air pollutant concentrations from a road with varying topography and roadside structures. The distance downwind (x-axis) is expressed in multiples of the height of the noise barrier studied (6 m for this figure).

Multiplying the x-axis values by 6 provides an estimate of downwind concentrations at distances in units of meters. The ground-level concentrations have been non-dimensionalized to represent inert pollutant dispersion. This figure was obtained from Baldauf et al. (2009), with Heist et al. (2009) providing additional details on the wind tunnel studies conducted.

Figure 7-1 highlights how roadside features can impact downwind pollutant concentrations under wind conditions normal to the source road. Notably, flat terrain, which would be representative of at-grade roads, shows the least disruption in dispersion, where relative ground-level concentrations are highest as on-road emissions are dispersed, with a Gaussian-type gradient, where concentrations decrease with increasing distance from the source roadway. At-grade road configurations would have the least complicated dispersion scenarios to consider while targeting maximum NO₂ concentrations, and thus be the most desirable setting for near-road NO₂ monitoring stations. The second most desirable near-road monitoring location is

adjacent to elevated roads on fill material with gently sloped walls, where maximum concentrations are found that are very close in value to concentrations found with at-grade locations. Those roadway designs that may be less preferable when considering near-road NO₂ monitor locations would be those where a site would be adjacent to elevated roads that are open underneath, or cut (or depressed) road beds (where deeper cuts or depressions likely present increasingly more significant impacts or complications on pollutant dispersion).

Recommendations on siting a monitor probe near above and below grade roads are discussed in Section 8.

7.2 Roadside Structures

In addition to the manner in which roadway design affects pollutant transport and dispersion, roadside structures may be present that also affect near-road pollutant concentrations. These structures include sound walls or noise barriers, vegetation, and buildings.

Physical barriers affect pollutant concentrations around the structure by blocking initial dispersion and increasing turbulence and initial mixing of the emitted pollutants. In wind tunnel studies such as that reported by



Baldauf et al. (2009), sample road configurations with noise barriers are shown to have the largest impacts on pollutant dispersion, relative to flat, at-grade roadway designs. In other situations, such as when winds blow along the roadway, roadside structures may channel emissions downwind, without much dispersion occurring normal to the road. Therefore, even if

siting criteria can be met at a site, the EPA suggests that monitor placement adjacent to these structures be avoided when possible, particularly if other, similar candidate near-road locations are available that do not have such roadside structures.

7.3 Vegetation

Vegetation along a road segment can affect on-road pollutant transport and dispersion. Winds flowing through vegetative structures can experience increased mixing and dilution due to the complex system of branches and leaves, while also leading to calmer winds behind the vegetation compared with similar winds in an open field situation. In addition, the branches and leaves can provide surfaces for particle deposition through impaction or diffusion as pollutants are transported through the vegetation.

7.4 Terrain

As mentioned in Section 7.1 (on roadway design), local topography is often a part of roadway design and can greatly influence pollutant transport and dispersion. However, large-scale terrain features, beyond the local roadway configuration, may also impact where peak NO₂ concentrations from on-road mobile sources can occur. The consideration of large-scale terrain in the siting process is more of a case-by-case issue for individual sites. In consideration of this issue, the EPA believes that state and local air agencies likely have a good understanding of large-scale terrain impacts on pollution dispersion in or within a CBSA, as these impacts would not be unique to near-road emissions, but also have effects on wider scale ambient monitoring.

In terms of making sure that larger scale terrain is considered in the near-road NO₂ monitoring site selection process, one example could be identifying multiple air basins within a single CBSA if present, and considering how individual basins may affect pollutant build-up and

dispersion. Another example might be considering roads through valleys, where, due to the increased potential for inversion conditions within the valley, higher near-road NO₂ concentrations may be found than what is found along alignments on the tops of hills, along hillsides, or in open terrain.

7.5 Meteorology

Evaluating historical meteorological data should be useful in determining whether certain candidate locations may experience a higher proportion of direct traffic emission impacts from a given target road segment due to the local winds. More specifically, an evaluation of local meteorology may also provide some indication on which side of an individual road segment under consideration, might experience a higher proportion of direct traffic emission impacts from a given target road segment. Most studies showing elevated pollutant concentrations near roads have focused on measurements when winds were from the road to the downwind monitor or receptor (typically along a line normal to the roadbed) to identify near-road gradients. These studies indicate that monitor placement very near the road, on the relative downwind side of the target road is typically appropriate when attempting to measure peak concentrations. In addition to relatively small scale impacts on a candidate road segment (upwind/downwind), state and local air agencies may also consider other meteorological impacts, such as the frequency of inversions, which can lead to increased potential for pollutant build-up due to limited atmospheric mixing.

Section 8. In the preamble to the final NO₂ rulemaking, it is noted that downwind monitoring was not required, but the EPA strongly encouraged it. The decision not to make that a requirement was driven by several reasons. One reason is because some

evidence suggests that wind direction may not always be a major factor in leading to peak concentrations in close proximity to a major roadway. Often, peak NO₂ concentrations may occur during stable, low wind speed conditions. Further, the turbulence created by vehicles on the road can lead to “upwind meandering” of pollutants, where a monitor upwind of the target road would still be characterizing on-road emissions. Finally, the EPA did not want such a restrictive measure in place which may not always be applicable. However, there are situations where meteorological patterns may warrant strong consideration for the relative downwind side of a target road segment. One example might be a road that runs relatively parallel to a coastline, where diurnal wind patterns, such as a sea breeze, may significantly impact pollutant build up and dispersion along that roadway. Another example might be roads in valley areas which are subject to air flows driven by diurnal mountain air flow patterns. Thus, historical wind directions should be considered in establishing NO₂ monitoring sites. In most cases, monitor placement on the climatologically down-wind side of a road segment is preferred; however, the EPA stresses that this should not preclude consideration of sites located in the predominant climatologically upwind direction in light of applicable site access, safety, and other logistical issues. Siting Criteria

The primary requirements related to horizontal and vertical probe placement for near-road NO₂ monitors are specified by the EPA in 40 CFR Part 58, Appendix E. Horizontal placement

of near-road NO₂ monitor probes, with respect to the target roadway, are required to be installed so “...the monitor probe shall be as near as practicable to the outside nearest edge of the traffic lanes of the target road segment; but shall not be located at a distance greater than 50 meters, in the horizontal, from the outside nearest edge of the traffic lanes of the target road segment.” The key component of this passage is that the monitoring probes are to be placed “as near as practicable” to the target road segment. Baldauf et al. (2009) note that a distance of 10 to 20 meters should be considered for near-roadway monitoring, and as such, the EPA strongly encourages state and local agencies to try to place near-road NO₂ monitor probes within 20 meters from target road segments when possible. Key requirements from 40 CFR Part 58, Appendix E are shown in **Table 8-1**.

Table 8-1. Key near-road siting criteria.

Near-Road NO ₂ Siting Criteria (per 40 CFR Part 58, Appendix E)	
Horizontal spacing	Per 40 CFR Part 58 Appendix E: “ <u>As near as practicable</u> to the outside nearest edge of the traffic lanes of the target road segment; but shall not be located at a distance greater than 50 meters, in the horizontal, from the outside nearest edge of the traffic lanes of the target road segment.” ***This TAD recommends that the target distance for near-road NO₂ monitor probes be within 20 meters of the target road whenever possible.***
Vertical spacing	Microscale near-road NO ₂ monitoring sites are required to have sampler inlets between 2 and 7 meters above ground level.
Spacing from supporting structures	The probe must be at least 1 meter vertically or horizontally away from any supporting structure, walls, parapets, penthouses, etc., and away from dusty or dirty areas.
Spacing from obstructions	For near-road NO ₂ monitoring stations, the monitor probe shall have an unobstructed air flow, where no obstacles exist at or above the height of the monitor probe, between the monitor probe and the outside nearest edge of the traffic lanes of the target road segment.

Vertical placement requirements of near-road NO₂ monitoring probes are “... to have the sampler inlet between 2 and 7 meters above ground level.” There are several situations where

the limits of the allowable vertical range for inlet probe heights may be appropriate. For example, if a candidate monitoring site is nearly at-grade with the target road, or if the target road is a cut-section road, the state and local air agency should consider placing the inlet probe closer to the 2 meter height limit above ground level. This recommendation is based on the information presented in Section 7.1, where the impact of the roadway designs will likely lead to peak concentrations more frequently occurring closer to ground level. Further, monitor probe placement at or near a 2 meter height above ground level is generally considered to be at or near “breathing height,” which is a human exposure consideration.

Alternatively, if a near-road monitoring station is being considered for placement adjacent to an elevated fill section of road, particularly where the elevated roadbed has vertical or sharply sloped walls, the state or local air agency should consider placing the inlet probe higher in the 2 to 7 meter range above the ground level so that the sampler inlet might be closer to the elevation of the target road surface, if they are immediately adjacent to the target road. This follows the rationale, as discussed in Section 7.1, where emission plumes from elevated roads may have peak concentrations aloft in winds normal to the roadway (due to eddy formation immediately downwind of the roadbed) with the core of the emission plume impacting the ground further downwind from the vertical or sharply sloped wall. In this situation, depending on the relative difference in height between the target road surface and ground-level at the monitor probe location, and the steepness of the grade between the two locations, the state or local air agency could also consider placing the monitor probe slightly further away from the target road to avoid situations where the inlet probe may be in the eddy cavity downwind of the elevated road structure, causing the emission plume to potentially pass over the inlet probe.

Per 40 CFR Part 58 Appendix E, near-road NO₂ monitor probes need to be spaced away from certain supporting structures and have an open, unobstructed fetch to the target road segment. In a majority of monitoring sites, gas analyzer inlet probes such as those used for NO₂, are placed on a monitoring shelter or on a tower on or adjacent to a monitoring shelter. However, for some monitoring site configurations, inlet probes may be placed upon walls, parapets, or other existing infrastructure, which could include a noise barrier in the near-road environment. In these cases, the probe must be at least 1 meter vertically and/or horizontally away from any supporting structure, and away from dusty or dirty areas. Further, for near-road NO₂ monitors, there will likely be some distance between the target road segment and the NO₂ inlet probe. It is required that there be an unobstructed air flow, or open fetch, where no obstacles exist at or above the height of the monitor probe and the outside nearest edge of the traffic lanes of the target road segment. Technically speaking, open fetch would be observed along a path directly between the road and the NO₂ inlet, normal to the roadbed. However, as the EPA noted in the preamble to the final NO₂ NAAQS rule, the NO₂ inlet will likely be influenced by various parts of the target road segment that are at a relative angle compared to the normal transect between the road and the NO₂ inlet. As such, increasingly open areas without obstructions along the length of the road segment on either side of the monitoring station are a desirable site characteristic. Therefore, when considering site locations, the recommended approach is for state and local air agencies to consider more than one linear pathway between the target road segment and the monitor probe, and to choose sites where the monitor probe will be clear of obstructions.

Section 9. Using Exploratory Air Quality Monitoring to Identify Roadway Segments for Near-Road Site Selection Evaluation

To provide increased confidence of the likelihood for measuring peak NO₂ concentrations at a particular location, agencies may elect to conduct air quality monitoring to either identify candidate near-road monitoring sites or evaluate candidate monitoring sites identified through the process described earlier in this TAD. A variety of fixed and/or mobile monitoring techniques can be used to accomplish this task, and they can be used in a variety of applications including a saturation study, a more limited and focused monitoring campaign (as was conducted as part of the near-road NO₂ pilot study), or through mobile monitoring. The methods that could be used in such exploratory monitoring campaigns include passive and active devices that provide integrated or continuous measurements. Saturation studies typically use a large number of low cost, portable samplers to “saturate” an area with sampling devices in order to identify the spatial variability of pollutant concentrations. In this case, the application could be to deploy many samplers or devices at a number of roadside locations to estimate which roadways might have relatively higher pollutant levels. Other exploratory monitoring studies might use a more focused approach to create data for comparison or evaluation at a smaller number of sites, such as those derived from the process in Section 6 using traffic data, and considering any subsequent physical reconnaissance. Mobile monitoring uses instrumented vehicles or moveable platforms to measure pollutant concentrations at multiple locations. In this case, such mobile monitoring could potentially be used to determine spatial variability of pollutant concentrations among a number of road segments. These methods may be used exclusively or in combination to aid in the site selection process.

9.1 Passive Monitoring

Passive sampling devices (PSDs) for the measurement of NO₂ have been used widely in saturation sampling applications, and in more focused applications, including near-road monitoring studies. PSDs are a relatively inexpensive method, requiring only modest hardware and infrastructure to utilize in the field, with the largest expense being laboratory analysis of the exposed sampling media. PSDs are small, lightweight, and do not require power to operate. These characteristics allow PSDs to be more easily deployed in saturation monitoring campaigns, where a relatively large number can be deployed near numerous road segments at almost any location for comparison. The primary limitation to these devices for near-road applications is the long exposure times needed to collect a sufficient sample for analysis. In typical urban areas, these samplers must be exposed to ambient air for three or more days, and traditionally are exposed for week-long or multi-week periods. As a result, PSDs are not able to directly reveal those locations experiencing short-term, 1-hr average NO₂ concentration peaks (which are part of the NO₂ NAAQS). However, generally speaking, using PSDs to differentiate long-term concentration variability among candidate near-road monitoring locations as part of the near-road site selection process can be useful. Several studies have compared PSDs with a Federal Reference Method (FRM) and other real-time monitors, with the accuracy and precision of these devices varying by application and the time averaging periods evaluated. The EPA believes that the use of PSDs, even though sample data are collected over longer time periods, can still be used in a comparative nature to help identify those road segments which may have a relatively higher probability of experiencing peak NO₂ concentrations on shorter time intervals.

A number of references (such as those listed below) can be consulted for more information on how to conduct passive sampling for a near-road evaluation, advantages and disadvantages of

this approach, and the precision and accuracy that can be anticipated when conducting this type of project. Some of these references focus on NO₂ applications; however, passive samplers can also be used for other contaminants if multi-pollutant monitoring is desired. Resources include the following materials:

- Quality Assurance Project Plan: Use of Passive Sampling Devices (PSDs) in a Near-Road Monitoring Environment, <http://www.epa.gov/ttn/amtic.nearroad.html>
- New York City Community Air Survey, <http://www.nyc.gov/html/doh/html/eode/nyccas.shtml>
- Mukerjee et al., 2009, “Field comparison of passive air samplers with reference monitors for ambient volatile organic compounds and nitrogen dioxide under week-long integrals” *J. Environ. Monit.*, 2009, 11, 220–227

9.2 Stationary Continuous or Integrated Monitoring

Several small, lightweight, and portable NO₂ analyzers are commercially available that which may be useful for conducting a saturation study, or a more focused study on a handful of road segments, to further evaluate potential near-road monitoring sites. Many of these samplers are battery-operated, so they have much of the same advantages of PSDs in the flexibility of monitoring at almost any location. These samplers cost more than PSDs; however, most are significantly lower than the cost of an FRM sampler. These samplers may also collect real-time, near real-time, or otherwise integrated NO₂ data; so the data collected from these samplers maybe more comparable to the 1-hr time average of the NO₂ NAAQS than data provided by PSDs. However, these sampling techniques are relatively new compared to FRM and PSD samplers, so the precision and accuracy of these devices is often uncertain and not well characterized, especially for near-road applications. Thus, if these samplers are chosen for the

purpose of establishing a near-road NO₂ monitoring site, care must be taken to ensure that the precision and accuracy of these devices is well characterized, which would include collocated sampling with an FRM or Federal equivalent method (FEM) sampler, collocation of the portable devices, and rotation of the portable samplers to evaluate potential individual sampler bias.

9.3 Mobile Monitoring

The use of mobile monitoring platforms for research and exploratory monitoring has increased in recent years. Mobile monitoring entails the placement of air quality sampling systems on-board a moveable platform (e.g., car/truck, bicycle, cart). This technique allows for a greater spatial coverage of monitoring over fairly short time periods. For some applications, the mobile platform is continuously moving, with short-term air quality measurements collected during this movement. This provides a broad spatial coverage of an area of interest over a short time period. In other applications, the moveable platform is rotated from location to location, collecting short or longer term measurements at each spot, where the time averaged measurements are typically on the order of minutes to hours at each location. Limitations of mobile monitoring often are identified to be the lack of simultaneous monitoring at multiple sites; as there is potential to miss maximum concentrations over the entire area of interest if changes occur in the strength or location of emissions over short time periods. In addition, these measurements may not be easily correlated to the maximum 1-hr average concentrations of interest for the NO₂ NAAQS if collected over short-term durations (1- to 5-second average concentrations). To address these limitations, some studies have incorporated the use of multiple mobile monitoring platforms, or integrated mobile and stationary monitoring.

In general, mobile monitoring studies tend to be much more expensive than PSD or other saturation studies using portable equipment. While few NO₂ mobile monitoring studies have

been conducted due to the lack of continuous instrumentation, these studies will likely increase with the availability of new real-time NO₂ monitors. Mobile monitoring may also be useful for conducting multi-pollutant assessments since a number of air quality samplers can be placed on a mobile platform for simultaneous use. If state or local agencies consider the use of mobile monitoring as a tool to assist in the determination of where a near-road NO₂ station might best be located, a number of key concepts and measurement routines should be considered. These concepts and routines include ideas like repeating travel loops over the course of hours and or days, and the determination of how much data collection will provide a sufficient amount for comparison purposes, among others. These concepts are described in peer reviewed literature, such as the Hagler et al. (2010) article (and references within); such literature should be considered as a template for how a mobile monitoring study might be conducted. Resources include the following materials:

- Hagler G.S.W., Thoma E.D., and Baldauf R.W. (2010) High-resolution mobile monitoring of carbon monoxide and ultrafine particle concentrations in a near-road environment. *J. Air & Waste Manage* 60, 328-336.
- Westerdahl D., Fruin S., Sax T., Fine P.M., and Sioutas C. (2005) Mobile platform measurements of ultrafine particles and associated pollutant concentrations on freeways and residential streets in Los Angeles. *Atmos. Environ.* 39, 3597-3610 (20). Available on the Internet at <http://www.sciencedirect.com/science/article/B6VH3-4G4N0HK-1/2/2f105ea20bb843af35c9586c0f810cac>.
- Westerdahl D., Wang X., Pan X., and Zhang K.M. (2009) Characterization of on-road vehicle emission factors and microenvironmental air quality in Beijing, China. *Atmos. Environ.* 43, 697-705.

Section 10. Using Air Quality Modeling to Identify Roadway Segments for Near-Road Site Selection Evaluation

Air quality modeling can be used in several different ways to aid in the near-road site selection process. One use could be to conduct dispersion modeling of several candidate near-road sites, such as those identified through traffic data evaluation and subsequent physical reconnaissance. The model output could be used to provide further confidence of the likelihood of measuring peak NO₂ concentrations, by comparing the relative concentrations among the modeled road segments. Another use of modeling could be to further refine locations for near-road stations along individual road segments, as necessary. A third application of modeling, although potentially time intensive, could be to model a larger number of road segments to identify those segments where peak NO₂ concentrations might be expected. This third application could possibly be performed in lieu of the traffic analysis suggested in Section 6 in order to generate a prioritized list of road segments for further evaluation. All three of these air quality modeling applications require the use of both a vehicle emissions model and an air quality dispersion model.

This section describes these applications in terms of EPA regulatory models (e.g., MOVES for vehicle emissions and the AMS/EPA Regulatory Model [AERMOD] for dispersion). We note that California maintains the Emission FACTors (EMFAC) model for predicting vehicle emissions in that state, and the California Air Resources Board (CARB) guidance should be consulted for using that model.

10.1 Motor Vehicle Emissions Simulator (MOVES) Model

EPA's MOtor Vehicle Emission Simulator (MOVES) is a computer model that estimates emissions from on-road motor vehicles, including cars, trucks, buses, and motorcycles.³

MOVES was released in December 2009 and replaces MOBILE6.2, EPA's previous emissions model.⁴ MOVES is based on an extensive review of in-use vehicle emissions data collected and analyzed since the release of MOBILE6.2. MOVES estimates emissions of NO_x and other pollutants based on vehicle type, age, and activity. It accounts for variations in speed, temperature, and other factors, and can do so at a high level of geographic resolution.

Accordingly, MOVES can incorporate a wide array of vehicle activity for each road segment.

MOVES includes various emission processes (running, start, brake wear, tire wear, extended idle, and crankcase) that are applicable in different contexts. Because the emphasis in this TAD is on high-traffic road segments, the emphasis of emissions modeling should focus on the NO_x emission processes prevalent on roadway segments: running exhaust and crankcase.⁵ For other pollutants, such as PM, hydrocarbons (HC), and CO, other emission processes are important. See Appendix C for further information on using MOVES for project-level analyses.

10.2 AERMOD Air Quality Dispersion Model

The purpose of this section is to provide guidance to state and local agencies who choose to use modeling to further inform the implementation of near-road NO₂ monitors. The information

³ See EPA's MOVES website for further information on downloading MOVES, the MOVES User Guide, and other technical documentation: <http://www.epa.gov/otaq/models/moves/index.htm>. For guidance documents, see <http://www.epa.gov/otaq/stateresources/transconf/policy.htm#project>.

⁴ This document uses "MOVES" to refer generically to any approved version of the MOVES model. This guidance is applicable to current and future versions of the MOVES model, unless EPA notes otherwise.

⁵ If other transportation facilities are evaluated (e.g., diesel truck or bus activity at terminals), then additional emission processes would be considered in MOVES.

provided here, along with the more detailed information in Appendix C, covers the selection of an air quality model, modeling domain (including receptor placement), characterization of emission sources, meteorological inputs, and inclusion of background concentrations. For this TAD, AERMOD was selected as the regulatory dispersion model. Promulgated in 2005, AERMOD is EPA's preferred near-field dispersion model for a wide range of regulatory applications in all types of terrain based on extensive developmental and performance evaluation. AERMOD is the recommended model for most mobile source modeling scenarios.⁶ . In regards to NO₂ mobile sources, AERMOD was used for the NO₂ Risk and Exposure Assessment (U.S. EPA, 2008) and performed generally well.

10.2.1 NO₂ Chemistry Using OLM or PVMRM Algorithms

NO to NO₂ conversion can be modeled explicitly in AERMOD using one of two methods, the Plume Volume Molar Ratio Method (PVMRM [(Hanrahan, 1999a, b); (Cimorelli et al., 2004)]) or the Ozone Limiting Method (OLM)⁷. These methods use NO₂/NO_x emitted ratios and background ozone concentrations to convert NO to NO₂ within AERMOD. For more information regarding the use of PVMRM and OLM, consult the following resources:

- the AERMOD User's Guide and addendum (Cimorelli et al., 2004),
- the material in Appendix C in this document, and

⁶ For example, EPA cites AERMOD as a recommended model when completing PM hot-spot analyses for transportation conformity analyses of highway and transit projects. See EPA's *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM_{2.5} and PM₁₀ Nonattainment and Maintenance Areas* (U.S. EPA, 2010a, 2010b).

⁷ Appendix D also discusses two conservative methods of calculating NO₂ concentrations based on information in Appendix W, Modeling Guidance.

10.2.2 the March 1, 2011 EPA memorandum, “Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard” which offers more guidance and background information on these two algorithms (U.S. Environmental Protection Agency, 2011). Promulgated in 2005, AERMOD is EPA’s preferred near-field dispersion model for a wide range of regulatory applications in all types of terrain based on extensive developmental and performance evaluation. AERMOD is the recommended model for most mobile source modeling scenarios.⁸ . In regards to NO₂ mobile sources, AERMOD was used for the NO₂ Risk and Exposure Assessment (U.S. EPA, 2008) and performed generally well. AERMOD and NO₂

On March 1, 2011, EPA issued “Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard” (U.S. Environmental Protection Agency, 2011) to provide clarification and guidance on the use of Appendix W guidance for the 1-hour NO₂ standard, including guidance for the implementation of OLM and PVMRM in AERMOD, inclusion of background concentrations, and other modeling guidance. Much of the information noted in the memorandum is presented in Appendix C.

10.2.3 Including Background and Nearby Sources in Analyses

While this section of the TAD has emphasized mobile source emissions, two other components usually considered in a modeling exercise are the inclusion of background concentrations and the modeling of nearby sources, including stationary sources and other mobile sources. The inclusion of background concentrations will affect the magnitude of cumulative (all sources) concentrations. Inclusion of nearby sources will also affect the magnitude of cumulative concentrations as well as possibly changing the location of maximum modeled concentrations or design values. Also, as described in Appendix C, the inclusion of

⁸ For example, EPA cites AERMOD as a recommended model when completing PM hot-spot analyses for transportation conformity analyses of highway and transit projects. See EPA’s *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM_{2.5} and PM₁₀ Nonattainment and Maintenance Areas* (U.S. EPA, 2010a, 2010b).

additional sources can also affect the competition among sources for ozone when using the PVMRM or OLM algorithms in AERMOD. More information on how to handle background and nearby source in a near-road centric modeling effort is presented in Appendix C.

10.3 Resource

U.S. Environmental Protection Agency (1985) Guideline for determination of good engineering practice stack height (technical support document for the stack height regulations, revised). Technical memorandum by the Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC, EPA-450/4-80-023R, June. Available on the Internet at <http://www.epa.gov/ttn/scram/guidance/guide/gep.pdf>.

Section 11. Physical Characteristics of Candidate Near-Road Sites

Using the list of prioritized candidate near-road segments produced in the process discussed in Section 6, and also under consideration of any supplemental exploratory monitoring and/or modeling that also might have been conducted, state and local air agencies should be in a position to perform a more detailed evaluation of potential near-road sites to further characterize and prioritize the list of candidate near-road site locations. Such characterizations and evaluations can be carried out through the use of electronic data resources including satellite imagery (e.g., Google Earth), mapping resources (e.g., Bing Maps or Google Maps), and/or ArcGIS, for example. In addition to these resources, the EPA also advises that state and local air agencies conduct reconnaissance in the field to characterize candidate sites. This section provides a suggested checklist for state and local air agencies to use in their reconnaissance. The EPA notes that some information suggested to be gathered to characterize any given road segment may already be reflected in any traffic data analysis that has been conducted.

11.1 Road Segment Identification

The road segment identifier is most likely part of the traffic analysis data. However, in some cases the identifying terms in the traffic analysis may not be the most commonly used or known terms. For practical means of understanding and communicating information about candidate near-road sites, it may be necessary to correlate the assigned roadway identifiers with any other useful identifying information and/or commonly used names for these traffic facilities. For example, using our Tampa, Florida example from Section 6 (Table 6-4, row 2), it is rather common knowledge that I-275 indicates “Interstate 275.” However, it might be useful during the evaluation process if the I-275 road segment was listed as “I-275/US 93” since US Highway 93

also uses the same corridor for the road segment used in this particular example (but is not listed in the traffic data table).

Another example might be for situations where a road is “named” and commonly referenced by that name, such as the Kennedy Expressway in the Chicago, Illinois area. In this example, while the road identifier may be “I-90/I-94” for a road segment on that stretch of expressway, it may more commonly be known as the Kennedy Expressway. When applicable, EPA recommends that state and local air agencies use the combination of given road identifiers along with more useful identification and/or commonly used labeling to aid in the site identification process. More detailed names should make it easier for interested parties to identify and understand which road segments are being described or characterized.

11.2 Road Segment Type

During reconnaissance it should be noted whether the road is a controlled access roadway, limited access expressway, limited or full access arterial, or other type of road. Controlled access roads (also referred to as freeways or sometimes expressways) are divided highways with full control of access. The control of access is established two ways: 1) by a lack of access to the roadway by any adjoining property (e.g., no driveways), and 2) the traffic on the road is free-flowing, where traffic flow is unhindered because there are no traffic signals or intersections that might cause traffic to stop. Access to these roads is typically provided by on and off ramps at interchanges with other roads. Limited access roads may have traffic signals, intersections, and access to adjoining properties; however, these access points are limited in number and location. Understanding the type of road for a candidate road segment can help determine the likelihood of safe, feasible monitoring shelter access. Controlled and limited access segments should not be

avoided for monitoring site consideration; however, the evaluation of these segments should consider how potential monitoring sites will be accessed and maintained.

11.3 Road Segment End Points

Similar to the suggestion to use additional information and increasingly common names or labels for road segment identification, it may also be helpful to use more descriptive language to describe, in name and location, those transportation facilities or boundaries that denote the end points to any given road segment (e.g., intersections, highway exits, highway mile markers, geopolitical boundaries). For example, using our Tampa, Florida example from Section 6, the highest-ranked FE-AADT road segment on I-275 (Table 6-4, row 2), is indicated to have end points at Bridge No–100128 and Bridge No–100110. Such traffic facility infrastructure identifications may not be commonly known or easily translated into physical and geographical locations to aid in understanding the extent to which the road segment extends. For practical means of understanding and communicating information about candidate near-road sites, it may be necessary to combine the DOT assigned traffic facility identifiers with any other commonly used names for these traffic facilities. In this example, it may be more useful to label Bridge 100128 as the “interchange of I-275/US 93 with Business 41/SR 685” and Bridge 100110 as the location where “Armenia Avenue crosses I-275.” The use of more commonly used or readily understood labeling will likely aid in the site identification process; making it easier for interested parties to identify and understand where a candidate road segment site is located.

11.4 Interchanges

State and local air agencies should note the presence of interchanges or road junctions within or at the ends of a particular road segment. Information could include the identification of the

intersecting or connecting road(s) and the type of interchange. There are multiple types of interchanges, including four-way (i.e., cloverleaf, stack, and diamonds) and three-way interchanges, among others. A robust but unofficial resource on the types of interchanges transportation agencies use in building transportation facilities can be found at [http://en.wikipedia.org/wiki/Interchange_\(road\)](http://en.wikipedia.org/wiki/Interchange_(road)).

11.5 Roadway Design

As discussed in Section 7.1, the roadway design can have a significant impact on pollutant transport and dispersion. During the reconnaissance of a road segment, state and local air agencies should note the design of the candidate road segment (e.g., at-grade; above-grade—on fill or open underneath; below-grade; or even a mix) including the notation of changes in design and the related local terrain along the length of the segment (if present).

In those cases where the road is above or below grade, air monitoring agencies should attempt to characterize the nature of the cut road or elevated road. For example, if a road is below grade, estimate the depth of the cut below the surrounding terrain and note the type of walls (i.e., sloped or vertical). For elevated roads, note whether the road bed is on a bridge or fill section, the height of the roadbed above the surrounding land, and for a fill section, whether the road is supported by vertical or sloped walls.

11.6 Terrain

Akin to roadway design, state and local air agencies should note the following:

- the type of terrain on which the candidate road lies
- the terrain immediately adjacent to the candidate road segment

- any larger-scale terrain features within which the candidate road may lie
- any larger-scale features that may potentially influence the candidate road

One example of a terrain feature to note is whether the road segment is along a grade along its length or for a portion of its length. Another example might be noting a road segment's proximity to hills, bluffs, canyons, ridges, or other topographical features that can influence local meteorology.

11.7 Roadside Structures

As discussed in Section 7.2, roadside structures can have a significant effect on pollutant transport and dispersion. Further, roadside structures can seriously impact the candidacy of a road segment to host a near-road monitoring station. During the reconnaissance of a road segment, state and local agencies should note all roadside structures throughout the length of the candidate road segment. Notation on the existence, type, location, length, and approximate height of any structures should be captured for any sound walls, vegetation, earthen berms, buildings, or other structure along each side of the segment.

11.8 Existing Safety Features

Safety in the near-road environment is a very important consideration in the installation of a near-road monitoring station (a more detailed discussion on safety issues is presented in Section 12.2). Safety of the travelling public on the road, the air monitoring staff members who service a near-road monitoring station, and the monitoring station itself should be a top priority. During the reconnaissance of a candidate road segment, state and local air agencies should take note of existing safety features along parts or all of the road segment, on each side of the road, including ditches, berms, guard rails, cable barriers, jersey barriers (temporary and permanent

concrete barriers), or other features. Placement of a monitoring station behind such safety features would be preferable when possible.

11.9 Existing Infrastructure

Existing structures, traffic related monitoring systems, and other highway maintenance facilities may already exist in the near-road environment along some candidate road segments. These pieces of infrastructure may provide a leveraging opportunity for a near-road monitoring site at a location that may already be accessible, have safety features, have power, and/or have other utilities, which might ease the installation of a possible near-road NO₂ station. Such infrastructure can include sign supports (traffic or billboard), light poles, automatic traffic counters, traffic camera installations, dynamic message signs, Road Weather Information System (RWIS) installations, rest stops, or other such locations. Additionally, state and local air agencies may be able to identify the location and nature of some RWIS infrastructure through U.S. DOT's Clarus System website (<http://www.clarus-system.com/>), depending upon individual state participation.

11.10 Surrounding Land Use

State and local air agencies should note the general or mixed use of land (e.g., urban or suburban residential, commercial, industrial, agricultural, forested) around candidate road segments during the reconnaissance process. Specific information (e.g., presence of schools, hospitals, low-rise or high-rise buildings) is also useful to note. In addition to the traditional land use categories noted above, state and local air agencies should also determine and note (through field reconnaissance and possibly emissions inventory review) whether any significant sources (off-road mobile or stationary sources) are nearby. Beyond traditional land use characterization,

the EPA also suggests that state and local air agencies identify the proximity of a candidate road segment to other heavily trafficked roads, areas of higher relative road density, and/or locations within or near central business districts or urban downtown areas.

11.11 Current Road Construction

The potential for future road construction on candidate road segments is discussed in Section 12. However, during candidate road segment reconnaissance, state and local air agencies should note any ongoing road construction along with any immediately apparent preparations for road construction.

11.12 Frontage Roads

Also called service roads or access roads, frontage roads typically run parallel to major highways, and may or may not be considered part of the major highway, thus they may or may not be controlled access or limited access roads. They are often one-way roads with traffic flowing in the same direction of the adjacent lanes of the partnering main-line travel lanes. They can provide access to property adjacent to major roads and connect these properties with roads which have direct access to the main roadway. Frontage roads can also provide a means for traffic in and around the properties adjacent to a major road to access that road, most often at interchanges. During candidate road segment analysis, the presence of frontage roads should be noted.

11.13 Meteorology

State and local agencies should attempt to understand the general climatological wind rose for candidate road segments, which can be used to aid in the determination of what might be dominant upwind and downwind locations along a particular segment. One method is to review

local and regional weather and climatological data collected by NOAA and any data collected by air agencies themselves at existing air monitoring stations in the area.

DRAFT

Section 12. Monitoring Site Logistics in the Near-Road Environment

A key component in the determination of whether a candidate near-road monitoring site is truly feasible is determining if an air monitoring agency will be able to access the desired location, whether the site would be safe for site operators and the public during routine operations, and whether there is sufficient availability of power and telecommunications services, or the ability to procure and install those services.

Per 40 CFR Part 58, Appendix E, section 6.4(a), "...the monitor probe shall be as near as practicable to the outside nearest edge of the traffic lanes of the target road segment; but shall not be located at a distance greater than 50 meters, in the horizontal, from the outside nearest edge of the traffic lanes of the target road segment." With emphasis on being "as near as practicable" to the target road segment, a number of candidate near-road sites are expected to fall within right-of-way properties under the jurisdiction and maintenance of state or local DOTs or other transportation authorities, collectively referred to as transportation agencies. This section provides background information regarding the access of right-of-ways, including associated terminology, safety guidelines, procedures, and expectations regarding the access to such properties. This section also includes suggestions on engaging and collaborating with transportation agencies to access highway property for installation of a near-road monitoring station in a right-of-way.

If a candidate near-road site is accessible without the state having to use the right-of-way (i.e., on property not otherwise managed or governed by a transportation agency), states will more than likely be able to treat the site access investigation as they would for any other traditional ambient air monitoring site. In these cases, the EPA still encourages states to make

special accommodations and considerations for safety such as those presented within this section. Terminology specific to this section is provided in **Table 12-1**.

Table 12-1. Terminology used in this section.

Term	Definition
Air rights	The term “air rights” is a legal term used to describe that area above (e.g., air space) or below the plane of the transportation facility and located within the right-of-way boundaries under authority of the appropriate highway agency. Air rights typically include access to a parcel of ground within the right-of-way.
Air space lease	The agreement between the managing transportation authority and another entity dictating the length and terms by which the requesting entity may have access to highway air rights.
Easement	An easement is a right to use property belonging to someone else, for a stated purpose, without owning that property.
Federal-aid Highway	Per 23 CFR 470.103, federal-aid highways are those that are part of the federal-aid highway system and all other public roads not classified as local roads or rural minor collectors.
Federal-aid Highway System	Per 23 CFR 470.103, the federal-aid highway system means the National Highway System and the Dwight D. Eisenhower National System of Interstate and Defense Highways (the “Interstate System”). Specific information on the National Highway System and the Interstate System can be found at http://www.fhwa.dot.gov/planning/nhs/ .
Right-of-way (ROW)	The right-of-way is a type of easement that gives someone the right to travel across property owned by someone else. In situations dealing with ROWs along major highways, the use of ROW space is typically governed or managed by state or local DOTs or other transportation authorities.

12.1 Accessing the Right-of-Way

The feasibility of a potential near-road NO₂ monitoring site requires the determination of whether a given location can be accessed. If the prospective location is within the ROW of an existing road, state and local air agencies will need to engage their respective transportation agencies to gain access to the air rights of that property. This would be most likely accomplished through a permitting process that would ultimately lead to the development and establishment of an air space lease (or permit). The right to use space within the ROW by public entities or

private parties for interim non-highway uses may be granted in air space leases, as long as such uses will not interfere with the construction, operation, or maintenance of the transportation facility; anticipated future transportation needs; or the safety and security of the facility for both highway and non-highway users. This means that state and local air agencies considering potential near-road sites within the ROW would need to work with their companion transportation agencies to consider near and long-term construction plans, potential interference with routine highway operations and maintenance due to the presence of a monitoring station, safety, and security of the highway ROW during the development of the lease agreement. The permitting and lease agreement process is likely different from state to state, or from one urban area to another; however, this process will likely consider similar factors and take some amount of time to complete, before physical access is granted to the state or local air agency. The U.S. Federal Highway Administration (FHWA) maintains information on air space access on the web at <http://www.fhwa.dot.gov/realestate/airguide.htm>.

When considering a site within the ROW, state and local air agencies should consider several different factors that may impact the ease of negotiating an air space lease. The first factor is physical access. It is anticipated that transportation agencies will prefer that any potential near-road NO₂ monitoring site in the ROW be planned in a manner that the site be made accessible from outside the ROW, or have accommodations that preclude the need to access the site from the primary travel lanes of the target road.

If it is determined during the evaluation of a candidate site that the installation of a locked access point (such as a gate) is required to access the ROW, the state or local transportation agency must submit justifications and obtain approval from FHWA, which is a formal federal action, if the facility is an interstate facility. FHWA's policies on changes in access to the

interstate highway ROW are maintained on the web at <http://www.fhwa.dot.gov/programadmin/fraccess.cfm>. It is noted that this requirement does not preclude the establishment of a monitoring station where access is only feasible from the target highway; however, an approach requiring the use of a new locked access point may be more preferable to a transportation agency in an air space lease negotiating process than a plan relying upon access solely from the target road.

A second factor to be considered for site feasibility and the impact on negotiating an air space lease is the availability of utilities. State and local air agencies need to determine whether utilities are already present, need to be relocated, or need to be installed to support the air monitoring station. Any activity to change or install utilities will require approval from the managing transportation agency. If the road segment in question is part of a federal-aid highway, the state or local transportation agency must ensure that any permits to install necessary utilities must comply with the appropriate federal regulation and FHWA policies. However, identifying potential site locations adjacent to, or otherwise near, existing infrastructure within the ROW with existing power may avoid some permitting procedures and possibly reduce utility related installation costs. More information on utility considerations, particularly with respect to bringing utilities into the ROW, can be found at <http://www.fhwa.dot.gov/programadmin/utility.cfm>

12.2 Safety in the Near-Road Environment

Near-road NO₂ monitoring sites must be safely sited for both the traveling public on the roadway and the personnel operating the monitoring site. Near-road monitoring sites must be accessible to station operators in a safe and legal manner, and not pose safety hazards to drivers, pedestrians, or nearby residents. Safety hazards to drivers can include obstructions to sight lines

and distractions, which can lead to accidents. Safety hazards to pedestrians include obstructions that block safe movement along the road or walkways. Safety hazards to monitoring site operators include factors which inhibit the safe entrance to or egress from a site and factors that could allow vehicles to encroach upon and damage the site infrastructure. Since near-road NO₂ monitoring sites may be located on transportation agency maintained ROW, as discussed above, it is anticipated that state and local air agencies will engage their respective transportation agency regarding access to such locations. During discussions on the potential access and use of locations within the ROW, safety should be a primary concern.

Transportation agencies deal with multiple roadway safety issues when building and maintaining traffic facilities. FHWA maintains a safety program addressing safety issues; more information can be found at <http://safety.fhwa.dot.gov>. However, of the multiple safety categories that are dealt with, the one category that may be most relevant with regard to the near-road NO₂ monitoring network is “roadway departure” safety. FHWA defines a roadway departure accident as a non-intersection crash which occurs after a vehicle crosses an edge line or a center line, or otherwise leaves the traveled way. Since near-road NO₂ monitoring stations are not on the road, but relatively near the outside edge of travel lanes, the roadway departure of vehicles likely poses the biggest safety risk to the travelling public, the air monitoring staff working at a near-road site, and the monitoring site infrastructure. Depending upon roadway design and terrain, there are multiple means by which transportation agencies can improve or increase safety within the ROW or at the edge of ROW space. Examples include roadway paving techniques (e.g., rumble strips or safety edging), increasing pavement friction, the use of retaining barriers, and maintaining open areas within the ROW which are called “clear zones.” With respect to near-road NO₂ monitoring stations, existing safety features provided by the local

terrain, man-made barriers, or clear zones should be considered as positive attributes to a potential site in the site selection process.

The terrain of a road segment can, in some cases, increase safety by reducing roadway departures that impact a near-road monitoring site. Such examples are ditches or berms made of earthen fill, which might exist between the roadway and the monitoring station. So long as these terrain features do not obstruct the fetch between the monitor probe and the target road, they may be viewed as positive attributes for a given candidate road site.

Man-made barriers or retainers in the ROW come in many forms, most of which can generically be referred to as longitudinal barriers. FHWA maintains a list of crash-worthy longitudinal barriers on the web at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/. Some examples of the many individual types of longitudinal barriers available include temporary and permanent concrete barriers, multiple configurations of steel and/or wood guardrails, water-filled barriers, and cable barriers. The presence of any type of longitudinal barrier, so long as it does not obstruct the fetch between the monitor probe and the target road, may be viewed as a positive attribute for a given candidate near-road site.

Clear zones are defined by FHWA to be an unobstructed, traversable roadside area that allows a driver to stop safely, or regain control of a vehicle that has left the roadway. The width of the clear zone (e.g., the distance between the outside edge of the road to an obstacle) is based on risk, which is derived from a roadway's traffic volume, design speeds, and the slope of the underlying and adjacent terrain. In practice, a clear zone is free of obstructions (including safety barriers) and would denote an area or distance from the road that a near-road monitoring station would be placed outside of, measured from the outside edge of the travel lanes. As a rule of

thumb, highways with no natural or man-made obstructions alongside the travel lanes typically might be prescribed to have a clear zone on the order of about 9 - 10 meters (30 feet) with maximum clear zone recommendations of approximately 13 meters (46 feet) for elevated fill roads.

Although FHWA provides a summarization of clear zones on the web (http://safety.fhwa.dot.gov/roadway_dept/clear_zones/#zones), clear zone guidance is created by the American Association of State Highway and Transportation Officials (AASHTO). AASHTO's *Roadside Design Guide* [also known as the "green book"; (American Association of State Highway and Transportation Officials, 2011)] contains more specific information on clear zones, providing variable clear zone distances based on traffic volume, speeds, and roadside geometry. **Table 12-2** and **Figure 12-1**, which are reprinted here with permission of AASHTO, show information on clear zones. As stated in the *Roadside Design Guide*, the table and curves depicted were based on limited empirical data; the clear zone distances suggest only an approximate center of a range of distances to be considered and not a precise distance to be held as absolute. In addition, clear zone distance recommendations do not preclude the establishment of monitoring stations at closer distances to the road; however, stations located within the clear zone will likely require the installation of safety devices (as previously discussed).

Table 12-2. Clear zone information in U.S. customary units (reprinted with permission from AASHTO).

Design Speed (mph)	Design ADT ^a	Foreslopes ^b			Backslopes ^b		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H ^c	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
40 or less	Under 750	7–10	7–10		7–10	7–10	7–10
	750–1,500	10–12	12–14		10–12	10–12	10–12
	1,500–6,000	12–14	14–16		12–14	12–14	12–14
	Over 6,000	14–16	16–18		14–16	14–16	14–16
45–50	Under 750	10–12	12–14		8–10	8–10	10–12
	750–1,500	14–16	16–20		10–12	12–14	14–16
	1,500–6,000	16–18	20–26		12–14	14–16	16–18
	Over 6,000	20–22	24–28		14–16	18–20	20–22
55	Under 750	12–14	14–18		8–10	10–12	10–12
	750–1,500	16–18	20–24		10–12	14–16	16–18
	1,500–6,000	20–22	24–30		14–16	16–18	20–22
	Over 6,000	22–24	26–32 ^d		16–18	20–22	22–24
60	Under 750	16–18	20–24		10–12	12–14	14–16
	750–1,500	20–24	26–32 ^d		12–14	16–18	20–22
	1,500–6,000	26–30	32–40 ^d		14–18	18–22	24–26
	Over 6,000	30–32 ^d	36–44 ^d		20–22	24–26	26–28
65–70	Under 750	18–20	20–26		10–12	14–16	14–16
	750–1,500	24–26	28–36 ^d		12–16	18–20	20–22
	1,500–6,000	28–32 ^d	34–42 ^d		16–20	22–24	26–28
	Over 6,000	30–34 ^d	38–46 ^d		22–24	26–30	28–30

^a ADT = average daily traffic.

^b The two most common slopes used in road construction are foreslopes and backslopes. The foreslope extends from the outside of the shoulder to the bottom of the ditch. The backslope extends from the top of the cut at the existing grade to the bottom of the ditch. The amount of slope in either the foreslope or backslope is the ratio of the horizontal distance (H) to the vertical distance (V).

^c Since recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of the slope. Determination of the width of the recovery area at the toe of the slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of the slope. While the application may be limited by several factors, the foreslope parameters which may enter into determining a maximum desirable recovery area are illustrated in AASHTO's *Roadside Design Guide*.

^d Where site-specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear zone shown in this table. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

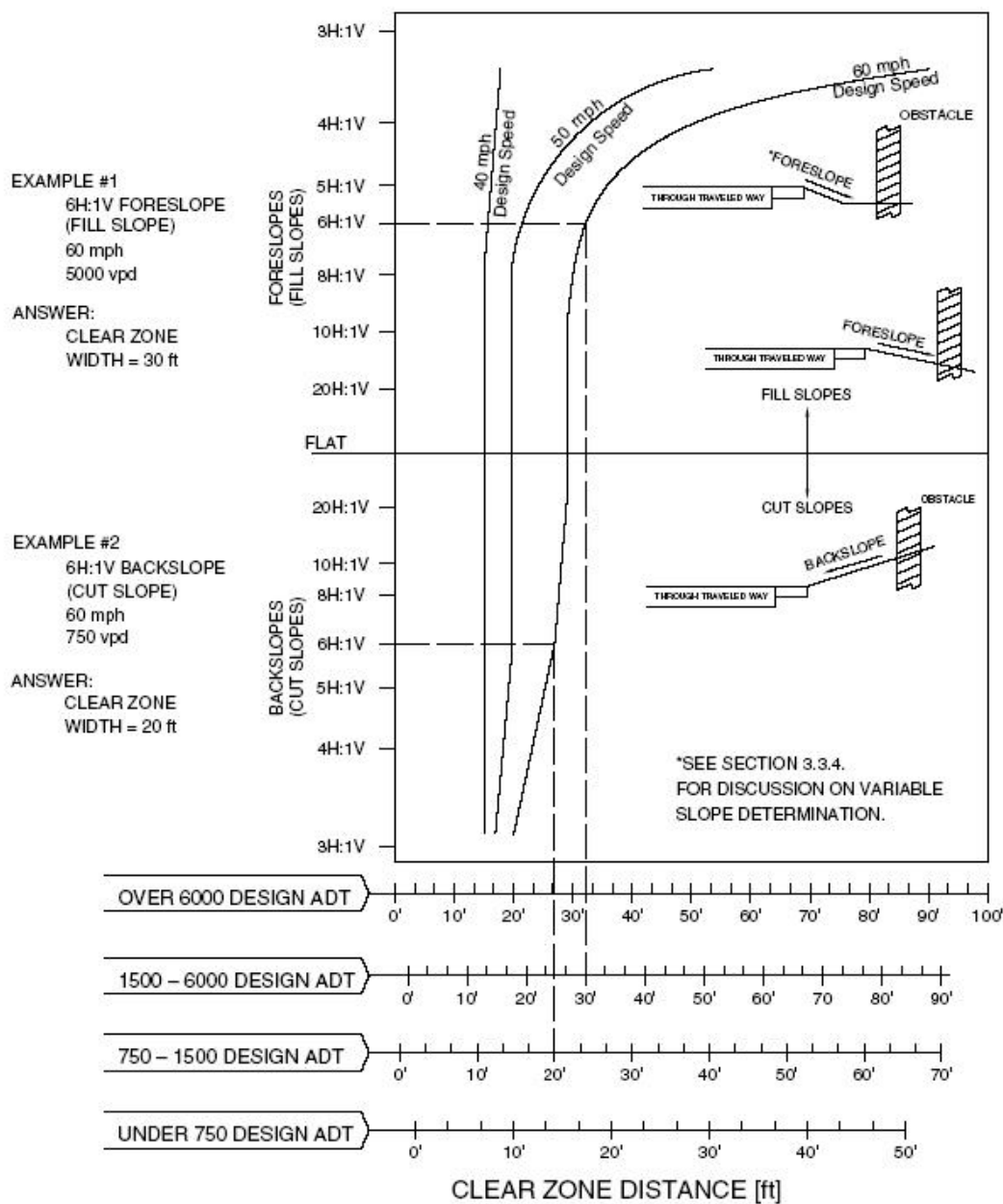


Figure 12-1. Clear zone distance curves (reprinted with permission from AASHTO).

In addition to the preceding material from FHWA and AASHTO, a state and local air agency may benefit from inquiring with their respective state or local transportation agency about

approved design manuals they might have that contain specific safety criteria and/or guidance that could be applied to any particular candidate road segment under evaluation.

The EPA stresses that safety is a top priority in all field operations. Ambient air monitoring operations in the near-road environment present additional safety issues that must be addressed in the site selection process. As such, the EPA recommends that state and local air agencies fully evaluate the presence of existing protection or safety features along candidate road segments. If appropriate safety features are not present, the state or local air agency will need to consult with their DOT to determine whether there is a need, and if so what the design and installation process might be for infrastructure additions or enhancement to ensure safety for all highway and monitoring station users. For example, if a longitudinal barrier does not exist along a candidate site, state and local air agencies should bear in mind that they are able to procure and install longitudinal barriers, with permission from and in coordination with their companion transportation agency, specifically to protect the near-road monitoring site. The EPA has learned that that these barriers are relatively inexpensive compared to other typical site installation costs. Further, given the importance of protecting the public, air monitoring staff persons, and the site infrastructure, air agencies can also consider allowable safety measures beyond standard practice to further reduce safety related risk.

12.3 Engaging a Transportation Agency

State and local air agencies will need to obtain permission from the appropriate transportation agency if a monitoring site is to be located within a ROW. Most often, this permission will come in the form of an air space lease (or permit) negotiated with the managing transportation agency. The following sets of questions and issues are intended to prepare state and local air agencies to engage transportation agencies, including those that will need to be

answered among the state or local air agency, the state or local transportation agency, and potentially FHWA.

- Who is the public authority responsible for the ROW?
- What are the transportation agency requirements for considering and approving leases (or permits) to allow for the subject installation?
- Is the near-road site within interstate highway ROW? If so, the request for a lease or permit to the responsible state or local transportation agency responsible for the ROW must include information FHWA requires to be addressed in the review and approval of such an action. These issues will likely include the air rights agreement, locked-gate access (as necessary), and compliance with applicable utilities accommodation and relocation policy.
- What other policies, procedures, standards, leases/permits required or desired by the managing transportation agency will need to be addressed?

In addition to the overarching questions listed above, there are some anticipated questions that transportation agencies may have about a potential ambient air monitoring station, and some suggested questions that air agencies should consider asking their transportation agency counterparts regarding individual candidate road segments as discussed next.

12.3.1 Questions a Transportation Agency May Have

There are a number of questions that state or local transportation agencies may have when first approached by a state or local air agency regarding the placement of an ambient air monitoring station in the near-road environment. Some anticipated questions might include, but are not limited to, the following:

- Who will own the monitoring equipment?

- How long would the air monitoring site be used/needed?
- What are the physical dimensions of the monitoring site and shelter?

(State and local air agencies need to consider the potential for multi-pollutant monitoring when preparing this information. Multipollutant monitoring in near-road NO₂ monitoring sites is discussed in Section 13.4 and Section 16.)

- What type of structure (shelter) will be installed at the site? (Pictures are useful here.)
- How often would air monitoring staff need to access the site?
- If there are no existing utilities at the candidate site location, who will prepare the request for permit, and subsequently pay for the installation of required utilities?
- Who will be financially responsible for the upkeep of the monitoring station? This includes routine operations, and the inspection, maintenance, and security of the site.
- Who would be responsible for any closure, removal, and relocation of the station, if necessary?

12.3.2 Questions to Ask Your State or Local Transportation Agency

There are a variety of questions that state and local air agencies may want to ask their partner transportation agencies about the long-term feasibility and access of a site within the highway ROW. Some general questions an air agency might want to ask include:

- What, if any, construction is planned along the candidate road segment that might impact traffic operations on the road, the safety of the monitoring site, or safe and efficient access to the monitoring site?
- What, if any, construction is planned on nearby road segments or to the CBSA transportation network that might impact traffic operations along the candidate site road segment?

- In the future, if access to the monitoring site is either temporarily or permanently affected by a highway project, what contingencies might be available for alternative access to the site or alternative sites along the same road segment?
- Will an air space lease, if awarded, be a one-time process, or will that lease need to be renewed on some interval? If it would require renewal, are there any particular criteria that might cause the renewal to be disapproved in the future?
- Under what conditions should or could safety features be added to a road segment if a near-road station is to be installed in the ROW? If a clear zone is currently in use, is that sufficient, or would additional safety features be allowed to be installed?
- If safety feature installation or improvements are desired, what types of features are available to be considered for installation (such as guardrails, barriers, etc.)?
- Are there any other safety provisions that an air agency would need to conform to if they routinely access and work on and within a monitoring station in the ROW?

Section 13. Prioritizing Candidate Near-Road Locations for Monitoring Site Selection

The EPA expects that by (1) following the traffic analysis procedures to aid development of a prioritized list of candidate road segments (described in Section 6), and (2) evaluating select candidate road segments through reconnaissance, possible use of optional evaluation tools (e.g., exploratory monitoring or modeling), and possible discussions with respective transportation agencies (discussed in Section 7 through Section 12); state and local air agencies will be in possession of sufficient information to begin to make informed decisions regarding the selection of near-road NO₂ monitoring sites.

The EPA expects that state and local air agencies will have a variety of options once they compile candidate site information. It is important to recall that the objective is to monitor as near as practicable to roads where peak, ground-level NO₂ concentrations are expected to occur. However, even with all the factors that can impact whether candidate near-road locations are feasible, undoubtedly some air agencies will have multiple candidate sites to choose from, and will have to begin narrowing their options by placing weight on one or more road segment characteristics over others. It is at this point in the site selection process that a number of other factors should be considered: population exposure, unique and background source influences, confounding data, and the potential for multi-pollutant monitoring. The EPA suggests using a site comparison matrix to aid in the site selection decision process. A matrix will help ensure that all available information is presented in a format easy for decision makers to review.

13.1 Considering Population Exposure as a Selection Criterion

Per 40 CFR Part 58, Appendix D, section 4.3.2(a)(1), “where a state or local air monitoring agency identifies multiple acceptable candidate sites where maximum hourly NO₂ concentrations

are expected to occur, the monitoring agency shall consider the potential for population exposure in the criteria utilized to select the final site location.” Therefore, when considering all the available information (particularly AADT, fleet mix, congestion patterns, roadway design, terrain, meteorology, and siting criteria) for which candidate locations are suitable for a required near-road NO₂ station, population exposure should be given subsequent consideration.

Specifically, among a pool of otherwise similar candidate near-road sites, the site that may represent a higher population exposure, or exposures to susceptible or vulnerable populations, should be given increased consideration.

Population exposure can be considered in a number of ways, all of which cannot be listed here. In some cases, the consideration of population exposure may be relatively straightforward. A hypothetical example might involve two segments, one in a rural or less populated area of the CBSA and one located in a more urbanized or more densely population area. In this example, the higher population exposure would lead a state or local air agency to give greater weight to the more urbanized site(s).

However, the EPA anticipates that in more cases than not, such a simple example will not be the reality for state and local air agencies. In more complicated situations, the use of publicly available demographic and socioeconomic data for the populations living along and near candidate road segments can be used to aid in considering population exposure as an additional selection criterion. One example might be to use census block information, particularly focusing on those census blocks that contain, or are adjacent to, candidate road segments, or are otherwise able to be spatially connected to one or more candidate road segments. The official source for census block data is the U.S. Census Bureau’s American Fact Finder website

(<http://factfinder.census.gov>). Data can be downloaded in batch format from the following URL:

(http://factfinder.census.gov/servlet/DownloadDatasetServlet?_lang=en). These data can then be associated with spatial files located at <http://www.census.gov/geo/www/tiger/> and finally displayed within GIS software. The instructions for downloading and spatially associating census data for use in GIS are maintained at <http://www.census.gov/geo/www/tiger/wwtl/wwtl.html>. An alternative data source and analysis tool for spatially utilizing census data in the near-road site selection process is gCensus, located at <http://gecensus.stanford.edu/gcensus/>. While not officially endorsed, gCensus provides census-level demographic information that can be downloaded and visualized in Google Earth. Further, since available socioeconomic data can be used by state and local air agencies, the EPA encourages state and local air agencies to determine sites that are located in areas with susceptible and vulnerable populations.

13.2 Unique Locations and Background Source Influences

In the evaluation process, state and local air agencies may encounter situations where certain road segments of interest have characteristics that make the location a unique source of elevated pollutant concentrations which is not representative of other near-road locations across the CBSA. These locations could be due to the close proximity of a substantial stationary source, non-road mobile sources, or roadway design features such as tunnel entrances and exits or toll plazas. In situations where a state or local air agency has a choice between road segments having similar potential for peak NO₂ concentrations, the air agencies should place a higher weight on sites that are most influenced by typical roadway activity rather than those that are heavily influenced by unique sources or features. This approach increases the probability that the chosen site can represent a larger population exposure within and across CBSAs. At the same time, the EPA also recognizes that state and local air agencies will better understand

whether candidate near-road NO₂ monitoring sites have unique characteristics that do or do not represent their respective CBSA. EPA encourages state and local air agencies to engage the EPA Regional staff for assistance in evaluating such a situation; however, the decision on the near-road NO₂ monitoring site location rests with the state or local air agency.

13.3 Confounding Information

There may be instances where state and local air agencies have data or insights that indicate that certain candidate near-road sites may be preferable to those identified through other technical analyses, including those suggested in this TAD. Such data may be from one or more sources including, but not necessarily limited to, traffic data analysis and projections, exploratory monitoring, modeling, or local knowledge. In cases where measured data (of sufficient amount, quality, and confidence) are available as compared to estimated, modeled, or otherwise approximated information, measured data may more reliable unless those data are suspect due to poor quality assurance or other reasons. An example of such a situation might be a comparison between exploratory monitoring and modeled data, where the exploratory monitoring would provide measured data that may differ with the modeling results. Ultimately, the EPA expects air agencies to use their best judgment when presented with confounding information to make the best decision for their individual case at hand. The EPA also encourages state and local air agencies to engage the EPA Regional staff for assistance in evaluating any such situation.

13.4 Potential for Multi-pollutant Monitoring

A number of pollutants and measureable metrics of interest that exist in the near-road environment, other than NO₂, are discussed in some detail in Section 16. Although this document specifically provides suggestions on siting required near-road NO₂ monitors, the EPA

also encourages state and local air agencies to consider the potential of a site to house other pollutant monitors and measurement devices. This would specifically be accomplished in the site selection process by considering the footprint and layout of the infrastructure of a near-road monitoring station. The EPA believes that the footprint of a typical NCore station (which houses analyzers for CO, ozone, SO₂, total oxides of nitrogen (NO_y), a variety of PM instruments [including PM_{2.5} and lead samplers], and meteorological gear, along with all the associated support equipment) may be a conservative approximation of a multipollutant site footprint. Although this NCore-type footprint can be bigger than a single pollutant shelter, the EPA believes, based on research experiences, that this should not typically create additional burden or restrictions for site installation versus a single gas pollutant monitoring shelter.

13.5 Candidate Site Comparison Matrix

Upon the completion of traffic data analysis, field reconnaissance, and the conclusion of any other evaluation efforts, the EPA recommends that state and local air agencies consider compiling their research for use in the final stages of the site selection process. A suggested approach is to create a candidate site comparison matrix. Such a matrix would consolidate the data collected in the evaluation process and present that information in a comparable format, creating a foundation for the rationale of why one site might be selected over another. The matrix would likely aid state air staff and other decision makers, and will also be a useful source of data supporting site selection discussion with the EPA, other stakeholders, and possibly the public. Further, the EPA anticipates that the matrix will be a useful reference for users of the data, who may want to further analyze the data for applications beyond NAAQS compliance.

The candidate site comparison matrix is recommended to include, at a minimum, traffic data, surveilled field information, site feasibility information such as permission for, or lack of, access

to individual candidate sites, safety issues (if applicable), probable distance between the inlet probe and the outside edge of the target road, and any other collected ambient data and/or modeled data. The matrix can be used to represent individual points along a road segment or for whole road segments under consideration. As such, a detailed matrix could have several candidate locations that are available along the same target road segment. **Table 13-1** includes a list of variables that could be included in the matrix.

Table 13-1. Suggested data for each candidate site entry in a site comparison matrix.

Site/Segment Parameters	Description of Parameter
Location	Describe if the entry is for a specific point along a road segment or if the entry is representative of a whole road segment. If the entry is for a point, provide a moniker and the latitude and longitude. If for a road segment, identify where the segment boundaries occur (e.g. intersection, mile marker, political boundary, etc.)
Road segment name	Provide given road name and common name (if applicable)
Road type	Type of road (controlled access highway, limited access freeway, arterial, etc.)
Road segment end points	Denote the location of the road segment end points, including any given names, common names, and the latitude and longitude of each individual end point.
AADT	Provide AADT, source of data, and vintage
HD counts	As available, provide HD counts, source of data, and vintage
FE-AADT	As available, provide FE-AADT, noting HD _m value used. If not the national default value, provide the source of data used to calculate the site-specific value.
Congestion information	Denote value and type (e.g., LOS, , or AADT by lane), data source, and vintage
Roadway design	Denote design type or types present (flat, elevated-fill, cut, etc.). If not flat, identify whether the configuration is a vertical or sloped boundary. Include the height (and degree of slope if applicable).
Terrain	Denote the nature of the terrain immediately around the road and also any larger scale terrain features of note
Meteorology	If the entry is for a point, denote the predominate winds and whether the point is relatively upwind or downwind. If the entry is for a whole segment, denote the orientation of the segment to the predominant winds.

Site/Segment Parameters	Description of Parameter
Population exposure	Denote any assessment of population exposure and/or likeness to other road segments throughout the CBSA
Roadside structures	Denote the presence of any roadside structures and the height, width, and length
Safety features	Denote any safety features present and the height, width, and length
Infrastructure	Denote existing infrastructure (light poles, billboards, etc.) and potential site proximity (distance)
Interchanges	Denote the presence of any interchanges within or at the end points of the target road segment and potential site proximity (distance), including traffic information if available (AADT, HD counts, etc.)
Surrounding land use	Denote surrounding land use (residential, commercial, etc.). Also note proximity to other large roads, areas of higher relative road density, and/or locations within or near central business districts or urban downtown areas
Nearby sources	If applicable, note nearby NO _x sources (type, tonnage, etc.) and potential site proximity (distance)
Current road construction	Denote any visible or known road construction at the candidate site location or along the target road segment
Future road construction	If known, denote transportation agency plans for any future road construction (including time frame for completion)
Frontage roads	Denote the presence of frontage roads, and whether those roads are included as part of the target road segment.
Available space – site footprint	Denote any limitations in the space available for a multipollutant monitoring station
Property type	Is it ROW or private property?
Property owner	Who manages or owns the property under evaluation?
Likelihood of access	Note the level of confidence and any uncertainties regarding the acquisition of access to a particular property
Other details/local knowledge	List any other pertinent details that may have bearing on why a particular candidate site may or may not be selected. This can include information that reflects a state or local agencies' own knowledge of the area or roads under consideration

Section 14. Final Near-Road Site Selection

The EPA expects that state and local air agencies will engage the EPA Regional staff during the site selection process (as needed) and when a site has been selected that will be reflected in annual monitoring plans. At a minimum, the EPA Regions will provide feedback on any near-road site selection listed in the annual monitoring plan before issuing a network plan approval letter, as is typically done. The availability of data supporting the rationale behind a site selection, such as that within the candidate site comparison matrix, will facilitate the review process.

Once a location has been selected for the installation, the EPA suggests that state and local air agencies prepare and include site record metadata about the near-road location (along with monitor record data) which would eventually be input into AQS for inclusion in annual monitoring plans. AQS manuals and guidelines, including information on required and optional metadata fields associated with monitoring sites and monitor records, are maintained by EPA at <http://www.epa.gov/ttn/airs/airsaqs/manuals/>. For new near-road NO₂ monitoring sites, the EPA requires that certain metadata are entered into AQS, as is the case for any new State and Local Air Monitoring Station (SLAMS) site. The new site information should be added to AQS online or via the AA Basic Site Information transaction with an action indicator of “I” for “insert.” If using a batch transaction, refer to the AA Basic Site Information for formatting; the required fields are presented in **Table 14-1**.

Table 14-1. Near-road site information required in AQS – metadata (AA – basic site information).

AQS Metadata (AA – Basic Site Information)	
Transaction Type	Horizontal Datum
Action Indicator	Source Scale
State Code or Tribal Indicator	Horizontal Accuracy
County Code or Tribal Code	Vertical Measure
Site ID	Time Zone
Latitude	Agency Code
Longitude	Street Address
UTM Zone	Land Use Type
UTM Easting	Location Setting
UTM Northing	Date Site Established
Horizontal Collection Method	

In addition to the basic site information required for every new SLAMS site in AQS, the EPA strongly suggests that air agencies also populate the AB Site Street Information metadata fields for near-road NO₂ monitoring sites. This can be done online in AQS via the Maintain Site → Tangent Roads tab or via the AB Site Street Information transaction with an action indicator of “I” for “insert.” If using a batch transaction, refer to the AB Site Street Information for formatting; the required fields are presented in **Table 14-2**. (Note that Tangent Street Number [also called Tangent Road Number] is merely used as a unique identifier supplied by the user [i.e., “1”, “2”, ..., “99”]; it does not refer to a physical street number.)

Table 14-2. Additional near-road site information in AQS – metadata (AB site street information).

AQS Metadata (AB Site Street Information)	
Transaction Type	Street Name
Action Indicator	Road Type
State Code or Tribal Indicator	Traffic Count
County Code or Tribal Code	Year of Traffic Count
Site ID	Direction from Site to Street
Tangent Street Number	Source of Traffic Count

For traffic-related data fields, state and local air agencies should utilize the data gathered as part of the site selection process. For location-oriented data fields (e.g., Street/Road Name) the EPA suggests that these fields reflect the target road segment. The Agency recognizes that a site may not have a traditional street number if it is within the ROW of a major interstate or freeway.

Before a site can go into "production" status on AQS, (meaning it can be seen by public users), it MUST have at least one monitor associated with it. This is accomplished by populating monitor record fields, as it done for any SLAMS monitor. Within the multiple data input formats that exist for monitor record fields, the EPA suggests that state and local air agencies ensure that the following fields for near-road NO₂ monitors be populated as noted:

- Monitor Objective – At least reflect that it is a “source oriented”
- CBSA Represented – Reflect the CBSA that the monitor is within
- Distance from Monitor to Tangent Road – As accurately as possible, reflect the distance, in the horizontal, between the inlet probe and the outside nearest edge of the target road segment
- Dominant Source – Reflect that the “mobile source” category is the dominant source

The EPA believes that full and accurate characterization of the monitoring site and the monitor itself will greatly improve the ability to use and analyze data at near-road NO₂ monitoring stations.

Section 15. Selecting a Second Near-Road Site

Per 40 CFR Part 58 Appendix D, CBSAs meeting one of the following criteria are required to have a second near-road NO₂ monitoring site:

- the CBSA has a population of 2.5 million or more persons
- the CBSA has a population of 500,000 or more persons and has one or more road segments of 250,000 AADT or greater

EPA recommends that these second near-road NO₂ monitoring sites be selected so that they are differentiated from the first near-road NO₂ monitoring site by one or more factors affecting traffic emissions and/or pollutant transport, such as fleet mix, congestion patterns, terrain, geographic area within the CBSA; or different route, interstate, or freeway designation.

The data gathered to select the initial near-road NO₂ monitoring site will be very useful in determining where to place a second site. The EPA's primary recommendation for a second site is to attempt to have the site represent as many of the characteristics listed above differently from the first site, without sacrificing the objective of measuring relative peak NO₂ concentrations in the near-road environment. In some cases, this could allow for the consideration of sites that may have characteristics considered to make the location more unique. Examples include but are not limited to: a site with potentially higher population exposure (including vulnerable and susceptible populations); a site with a different fleet mix (e.g., high LD component); a site nearer to an area-wide monitoring location, as applicable (for relative gradient assessment); or a site with relatively unique features.

Section 16. Multipollutant Monitoring at Near-Road Monitoring Stations

The EPA has expressed the intent to pursue the integration of monitoring networks and programs through the encouragement of multipollutant monitoring wherever possible. This is evidenced by actions taken in the 2006 monitoring rule that created the NCore network, the expression of the multipollutant paradigm in the 2008 Ambient Air Monitoring Strategy for State, Local, and Tribal Air Agencies, and through recent rulemakings where minimum monitoring requirements have been proposed in a manner that would either require or strongly encourage multipollutants monitoring within SLAMS. Multipollutant monitoring is viewed by the EPA as a means to broaden the understanding of air quality conditions and pollutant interactions, furthering our capability to evaluate air quality models, develop emission control strategies, and support research, including health studies.

This section of the TAD discusses a number of pollutants of interest in the near-road environment due to their direct emission by on-road mobile sources, or the formation from or interaction with on-road mobile source emissions. The CASAC AAMMS, in their review of the EPA's "Near-road Guidance Document – Outline" and "Near-road Monitoring Pilot Study Objectives and Approach" (CASAC AAMMS review dated November 24, 2010, located at [http://yosemite.epa.gov/sab/sabproduct.nsf/ACD1BD26412312DC852577E500591B37/\\$File/EP-A-CASAC-11-001-unsigned.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/ACD1BD26412312DC852577E500591B37/$File/EP-A-CASAC-11-001-unsigned.pdf)), stated that "CASAC recognizes the importance for public health of better characterizing near-road pollutant concentrations." Subsequently, the CASAC AMMS held public teleconferences (September 29th, 2011 and November 17th, 2011) to discuss their review of the August 11th, 2011 draft version of this TAD (<http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/bea1681f1769e6f185257781005fcf8d!OpenDocument&TableRow=2.0#2>). In response to a charge

question regarding the relative priority for measuring other pollutants or other metrics of interest in the near-road environment, should state and local air monitoring agencies choose to invest in additional measurements, the CASAC AMMS suggested three pollutant groups, with relative priority (i.e., primary, secondary, and tertiary), to provide some guidance to air agencies choosing to conduct multipollutant monitoring (**Table 16-1**). These pollutants or metrics are discussed in this section, including definitions, basis of interest, and measurement methods.

Table 16-1. CASAC AMMS’s recommended priorities for multipollutant monitoring at a near-road site.

Priority	Pollutants
Primary	NO and NO ₂ (where NO ₂ is required), CO (required in a subset of near-road NO ₂ monitoring sites), ozone, and meteorology (wind speed, wind direction).
Secondary	Air toxics (at least benzenes, toluene, ethyl benzene, and xylenes), black carbon, ultrafine particle distribution (preferred) or ultrafine particle number concentration, and traffic counters (if the site is not already in proximity of a fixed transportation agency traffic counting device).
Tertiary	PM _{2.5} and PM _{10-2.5} , CO ₂ , and organic and elemental carbon (OC and EC, respectively).

16.1 Nitrogen Dioxide (NO₂)

NO₂ is an important target of ambient air monitoring because of its adverse impact on human health. Scientific evidence links short-term NO₂ exposures with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Further, some health studies have linked NO₂ exposure to increased visits to emergency departments and hospital admissions for respiratory issues.

NO₂ is one of a number of oxidized nitrogen species. Scientifically, nitric oxide (NO) and NO₂ are collectively referred to as NO_x, where NO + NO₂ = NO_x. However, there are other oxidized nitrogen species in the ambient air including nitric acid (HNO₃), nitrous acid (HNO₂), nitrous oxide (N₂O), peroxyacyl nitrates (PANs), and organic nitrates. These “other” oxidized nitrogen species are collectively known as NO_z. The entire family of oxidized nitrogen species

is known as NO_Y, which may operationally include some particulate nitrate species with respect to measurements of NO_Y; where $NO_Y = NO_X + NO_Z$.

NO₂ is the key focus of this document because of its role as the indicator of the oxides of nitrogen NAAQS, and the requirement to measure NO₂ in the near-road environment where, as noted in Section 1, the EPA recognized that roadway-associated exposures account for a majority of ambient exposures to peak NO₂ concentrations. The near-road environment is of interest because motor vehicles are significant contributors to the total NO_X and NO₂ inventory in the US. In tailpipe emissions, which are primary emissions, the majority of NO_X exhaust is in the form of NO. NO₂ quickly forms by photochemical reaction in the ambient air from the reaction of NO and ozone (O₃), and also through other photochemical processes. Although all motor vehicles emit NO_X, heavy-duty (diesel) vehicles emit more NO_X on a per vehicle basis than gasoline powered vehicles. Further, primary NO_X emissions from newer technology heavy-duty diesel engines with after-treatment devices may contain a much greater percentage of NO₂ in the exhaust (although the total amount of NO_X is reduced) than older diesel engines. Thus, NO and NO₂ will be present in varying concentrations in the near-road microenvironment.

In the current SLAMS network, NO₂ is almost exclusively measured using the chemiluminescent NO_X analyzer, which is a FRM. In the chemiluminescent FRM, NO₂ is measured by difference, as the NO₂ analyzer is only capable of measuring NO directly. The analyzer directly measures NO by introducing ozone to the sample stream, where the reactions between the two compounds releases energy in the form of light (chemiluminescence). In order to determine the amount of NO₂ in the ambient air, the analyzer will first detect the amount of NO in the ambient air.

Next, the analyzer re-routes the incoming ambient air stream through a heated converter (usually containing molybdenum) which reduces the NO₂ in the air stream to NO. The analyzer then detects all NO in that air stream that has passed through the converter. The ambient NO₂ concentration is determined by subtracting the original amount of NO measured in the unconverted air from the amount measured in the air that was passed through the heated converter, where the available ambient NO₂ was reduced to NO.

A known drawback to the traditional chemiluminescent measurement technique is that other NO_Z species, if present in the heated converter, will also be reduced to NO; meaning reduction by the heated converter is not specific to just NO₂. Thus, if a significant amount of NO_Z species are present in the ambient air, some of those species may make it to the heated converter and erroneously be counted as NO₂ when the analyzer determines the NO₂ concentration by difference. The EPA does not believe this measurement bias is a significant concern in the near-road environment (and typically in many urban sites) because the gaseous NO_Y species present are dominated by NO and NO₂, due to the proximity to the emission source (e.g., vehicles on the road). This measurement bias is of greater concern when measuring so-called “aged” air masses, where there has been time for NO_X emissions to be further oxidized into other NO_Z species.

There are other techniques that are commercially available to measure NO₂; however, as of the production of this document (circa December 2011), there are no other approved methods for NO₂ measurement by which the data could be used to determine compliance with the NAAQS. One of the available methods is a photolytic-chemiluminescent analyzer. This method, like the traditional chemiluminescent analyzer, can only directly measure NO. However, the photolytic-chemiluminescent analyzer uses a photolytic converter (instead of a heated metal converter) to reduce NO₂ to NO for measurement. The advantage that this method has over the traditional

chemiluminescent analyzer is that the photolytic converter is specific to NO₂, and does not reduce other NO_z species to NO, removing the potential for bias, if NO_z species are present.

Another commercially available method to measure NO₂ is the Cavity Ring-Down Spectrometer (CRDS). The CRDS uses the measured decay of laser light at a specific wavelength due to NO₂ absorption to determine the NO₂ concentration in the sampled air.

Beyond these two examples, other laser-based techniques are available to measure NO₂, although they are largely still considered to be research-grade instruments. The EPA plans to continue to work with academia and measurement technology vendors to improve measurement techniques, increasing the accuracy, precision, specificity, and speed of these next generation measurement technologies. Eventually, the EPA hopes that the advancement of such measurement technologies will lead to their consideration as reference or equivalent methods as they are ready.

16.2 Carbon Monoxide (CO)

CO is a colorless, odorless gas emitted from combustion processes. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. In addition, CO is a useful indicator of the transport and dispersion of inert, primary combustion emissions from on-road mobile sources, as CO does not react in the near-road environment. The majority of CO emissions come from mobile sources, where approximately 60% of the national inventory is attributable to on-road mobile sources (per the 2008 National Emissions Inventory). While all motor vehicles emit CO, the majority of mobile source CO is from light-duty, gasoline-powered vehicles, where LD vehicles produce more CO on a per vehicle basis than HD vehicles. Ambient CO measurements are routinely taken by analyzers

using gas filter correlation methodology, which relies on infrared (IR) absorption of CO at a specific radiation wavelength. This method has been in use since the 1970s; the current ambient CO compliance monitoring network is wholly comprised of analyzers based on this infrared absorption method. Of these analyzers, there are currently two types of IR absorption analyzers in use: the standard analyzer and a more recently commercialized “trace-level” line of analyzers. Standard analyzers have levels of detection on the order of 0.5 to 1 ppm, while the trace-level analyzers have levels of detection down to approximately 0.04 ppm.

While trace-level analyzers are strongly encouraged for use in the CO monitoring network when possible, standard CO analyzers are expected to be sufficient for use in the near-road environment, where ambient CO levels are expected to be relatively higher than at other locations more representative of area-wide spatial scales.

On August 12, 2011, the EPA promulgated minimum monitoring requirements for CO in the near-road environment. Per 40 CFR Part 58 Appendix D, one CO monitor is required to be co-located with a near-road NO₂ monitor in CBSAs having populations of 1 million or more persons. State and local air agencies can make a request to the EPA Regional Administrator to locate a required CO monitor to another near-road location in that CBSA if they can provide quantitative evidence in support of that request. However, the EPA expects that in most cases, state and local agencies will find it advantageous to leverage the near-road NO₂ infrastructure and also conduct multipollutant monitoring at their near-road NO₂ monitoring site.

16.3 Ozone

Ozone is not usually emitted directly into the air, but created at ground-level by a chemical reaction between NO_x and volatile organic compounds (VOCs) in the presence of sunlight. NO_x

and VOCs are emitted by mobile sources, among others. Ozone can trigger a variety of respiratory health problems; worsen bronchitis, emphysema, and asthma; reduce lung function; and inflame the linings of the lungs. Ozone is routinely measured in situ using photometry or chemiluminescence on a sub hourly to hourly sampling frequency. Ozone measurements are not typically collected for near-road applications. The presence of elevated NO concentrations in the near-road microenvironment typically leads to lower ozone concentrations due to “ozone scavenging” as part of the formation of NO₂ from NO and ozone. However, Ozone measurements may be useful in select circumstances to support health studies investigating the role of ozone and other co-pollutants on adverse health effects given the potentially lower concentrations of this pollutant relative to other pollutants in this microenvironment. Ozone measurements may also aid in increasing the understanding of NO₂ concentrations, NO₂ formation behavior, and broader photochemistry processes in the near road environment.

The EPA notes that while the measurement of ozone in the near-road environment would provide data that could be useful for furthering the understanding of photochemistry in the near-road environment, and would also provide data that could be compared with the NAAQS, the monitor would not meet minimum monitoring requirements for ozone (which calls for area-wide monitors) as prescribed in 40 CFR Part 58 Appendix D.

16.4 Meteorological Measurements

Meteorological data measured on-site at a near-road monitoring station can provide important information that can be used to characterize the pollutant data being measured at the station. As part of the CASAC AAMMS review, the panel stated that “the AAMMS believes meteorological parameters (wind speed and direction) should be one of the highest tier measurements considered as part of [the near-road NO₂] network.” A key advantage to having

meteorological data collected on site would be the ability to correlate the occurrence of peak NO₂ concentrations (and other pollutant peaks) to wind conditions. Data analysis of the collected pollutant data will be greatly enhanced by knowing if winds are calm, parallel to the road, or at any other angle making the monitoring site relatively upwind or downwind when peak NO₂ concentrations are measured. Although meteorological measurements were originally proposed to be required at near-road NO₂ monitoring sites, the EPA did not ultimately require them within 40 CFR Part 58.

However, the EPA strongly encourages states to measure meteorological parameters at near-road sites whenever possible. The EPA suggests that state and local air agencies try to measure wind speed, wind direction, temperature, and relative humidity, at a minimum (which matches those parameters required at NCore stations). If possible, other measurements such as precipitation, solar radiation, and barometric pressure, among others should be considered as well. More information on meteorological parameters, measurement techniques, and related quality assurance can be found in EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements* (U.S. Environmental Protection Agency, 2008b).

16.5 Air Toxics

In addition to some criteria pollutants, motor vehicles emit a large number of other compounds which can cause adverse health effects such as air toxics (or hazardous air pollutants). A discussion and listing of potential air toxics of concern for near-road monitoring can be found in the EPA's Mobile Source Air Toxics (MSAT) Rule (U.S. Environmental Protection Agency, 2007). These pollutants include VOCs, semi-volatile organic compounds (SVOCs), and organic and inorganic PM constituents. Reasons for monitoring these pollutants

for a near-road program include concerns over adverse human health effects, ecological effects, and the evaluation of the effectiveness of mobile source control programs.

Air toxics span the entire range of pollutants present in the atmosphere; they are present as particles, gases, and in semi-volatile form. No one measurement method captures all air toxics of interest in a near road environment. This section discusses potential monitoring activities for a number of classes of air toxics, but a discussion of all potential air toxic compounds identified in the MSAT rule is beyond the scope of this document.

Typical VOCs of concern for near-road monitoring include, but are not limited to, benzene, toluene, ethyl benzene, xylenes, styrene, 1,3-butadiene, and various aldehydes. These air toxics can contribute to long term health issues (e.g., cancer) and are also ozone precursors. A more detailed listing of potential VOCs of health concern is included in the MSAT Rule.

VOCs are typically measured by collecting ambient air using evacuated canister sampling and subsequently analyzing the samples using a gas chromatograph (GC). Sampling frequency can range from 1 hour, for automated systems, up to 24 hours. For evacuated canister sampling, the sample collection time can vary from an instantaneous grab sample to averaging times of more than 24 hours depending on the collection equipment used. Auto-GCs can be used to measure select VOC pollutant concentrations semi-continuously at a monitoring site. A number of manufacturers also advertise semi-continuous analyzers for one or more VOCs of interest using various GC technologies.

Aldehydes emitted from motor vehicles include, but are not limited to, formaldehyde, acetaldehyde, and acrolein. A more detailed listing of aldehydes with potential health concerns is included in the MSAT Rule. These pollutants are also formed through secondary production in the atmosphere. Aldehydes are typically measured using cartridges containing dinitrophenyl

hydrazine (DNPH). In addition, other methods, including evacuated canisters and cartridges with dansylhydrazine (DNSH), have been used to measure ambient concentrations of some of these compounds. Sample collection periods of 24 hours or more are typically required for assessing ambient aldehyde concentrations, although a few manufacturers advertise semi-continuous analyzers for select compounds. Accurate acrolein measurements remain a challenge. Measurements of these pollutants have indicated concentrations are elevated near heavily trafficked roads.

SVOCs present in near-road emissions are naphthalene and other polycyclic aromatic hydrocarbons (PAH). SVOC sampling is done using XAD/PUF cartridges within high volume samplers over 24-hr sampling periods. The XAD/PUF cartridges are extracted and analyzed using a gas chromatograph with a mass spectrometer, GC/MS.

Toxic metals are present in PM_{2.5} and PM₁₀ samples, along with other elements (such as soil components). These toxic metals can be emitted from brake wear, tire wear, engine wear, and oil and lubricant combustion. Inorganic PM samples are usually collected on filters using high-volume samplers and longer sampling times to collect sufficient mass for elemental analyses. Higher frequency monitoring methods, sub hourly to multiple hours, are developed, but not in wide use. Concentration gradients near roads of these toxic metals have not been widely studied in real-time. Metal deposition has been shown to have a similar gradient to other motor vehicle related pollutants near roads.

16.6 Black (or Elemental) Carbon

The graphitic-containing portion of PM, represented by black carbon (BC) or elemental carbon (EC), also referred to as “soot,” is emitted in motor vehicle exhaust. BC and EC are

operationally-defined. BC and EC are of interest because they serve as a measure of diesel particulate matter (DPM). Long-term (i.e., chronic) inhalation exposure to diesel exhaust (combination of gases and particles) is likely to pose a lung cancer hazard to humans, as well as damage the lung in other ways depending on exposure. Short-term (i.e., acute) exposures can cause irritation and inflammatory symptoms of a transient nature, these being highly variable across the population (<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060>).

Although BC and EC are primarily associated with emissions from heavy-duty diesel engines, a portion of all motor vehicle combustion emissions contains these constituents. BC is measured through light absorption, while EC is measured thermally. BC measurements can be made sub-hourly to hourly, while EC measurements are typically hourly to daily.

Other sources of BC or EC exist in urban areas (such as wood smoke), but emissions from motor vehicles usually dominate these sources in near-road air quality, thus making BC or EC measurements a useful parameter for identifying impacts from motor vehicle emissions.

16.7 Ultrafine Particulate Matter (PM)

PM emitted through the combustion process occurs initially in the ultrafine size range (i.e., less than 0.1 μm in diameter) and a very large number of these small particles are emitted. Despite the large number of ultrafine particles emitted, the impact on PM mass is negligible. Research has shown that PM number concentration measurements often provide a good indication of primary PM exhaust emissions from motor vehicles. Several health studies suggest that ultrafine particles may lead to adverse health effects. A number of devices exist to measure PM number concentrations, ranging from inexpensive industrial hygiene monitors to research-grade ambient air monitors (e.g., condensation particle counter, differential mobility analyzer).

Most of these devices can provide number concentration measurements in near real-time, while some devices are capable of providing particle number concentrations within specific size bins. When comparing measurements from different devices, any differences in particle size ranges detected must be noted. Measurements show that as the distance or transit time from emission to sampling increases, the size distribution shifts to larger particle diameters.

16.8 Traffic Counters and/or Cameras

Traffic counting devices and/or traffic cameras are another non-pollutant measurement that could be useful to an air agency to aid in characterizing measured pollutants at a near-road monitoring site. Understanding traffic behavior can help analysts better understand measured pollutant concentrations, such as the correlation of peak NO₂ readings to time periods when traffic is heaviest and/or experiencing increased congestion. There are a number of direct-measure methods used to characterize traffic including over the road tube counters, imbedded devices such as contact closure loops for counts or piezo-electric sensors used for weigh-in-motion, speed and red light cameras, and vehicle classification and counts. These methods are used by placing the sensors on or within the road surface of active travel lanes.

Unless a transportation agency has installed (or plans to install) on-road or embedded devices on a target road segment, the EPA does not encourage air agencies to pursue the use of such methods to gather traffic count information. However, there are remote sensing methods available to characterize traffic that use radar or camera based technology. These methods are able to be installed along-side of roads (such as on a meteorological tower or monitoring shelter) and can look down on the target road segment to characterize the traffic. The sophistication of remotely sensing instruments is variable, but the EPA suggest that if such a device is investigated for use, it should be capable of making total traffic counts for at least an hourly interval. Other

data metrics that would also be useful include the ability to segregate HD from LD vehicle counts and those methods with sub-hourly time resolution capability.

The EPA envisions any air agency collecting such data should do so only for the internal use of analyzing air quality data, and not to broadcast traffic data publicly in a manner that is independent of their local transportation agency. In some cases, the local transportation agency might be in a position to collaborate with an air agency that is looking to collect traffic data for a particular road segment where no traffic data is currently being collected. In such a case, there may be a synergistic advantage for both the air agency and the transportation agency; allowing the air agency to gather traffic data for air quality analysis with the support of a transportation agency, while the transportation agency may gain another source of traffic data for their use as well, at no cost to them. The EPA encourages state and local air agencies to pursue such collaboration if traffic data collection is conducted at near-road monitoring sites.

16.9 Particulate Matter (PM) Mass

PM is a complex mixture of small particles and liquid droplets comprised of sulfates, nitrates, acids, ammonium, EC, organic carbon (OC) compounds, trace elements such as metals, and water. The size of particles is directly linked to their potential for causing health problems. Particles that are 10 micrometers in diameter or smaller are of concern because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. Motor vehicles emit significant amounts of PM through combustion, brake wear, and tire wear. Motor vehicles may also contribute to elevated near-road PM concentrations by re-suspending dust present on the road surface.

In the United States, the NAAQS regulates ambient concentrations of PM with an aerodynamic diameter of 10 µm or less (PM₁₀) and PM aerodynamic diameter of 2.5 µm and less (PM_{2.5}). Both of these PM size fractions are emitted by motor vehicles. In general, PM from combustion is in the PM_{2.5} size fraction, with combustion-emitted particles typically being ultrafine particles (PM having a diameter less than 0.1 µm). These ultrafine particles contribute little to ambient PM_{2.5} mass concentrations, contribute significantly to PM number concentrations, and can impact the chemical composition of the PM_{2.5} mass collected near the road relative to urban background conditions. Ultrafine particles tend to exist as disaggregated particles for very short periods of time (minutes) and rapidly coagulate into accumulation mode particles. Accumulation-mode PM that is secondarily formed from motor vehicle combustion emissions may have a greater impact on PM_{2.5} mass concentrations that might be collected within the near-road environment and further downwind from the source road. PM emitted through mechanical processes of vehicle operation (e.g., brake wear, tire wear, re-suspended road dust) will tend to be in the PM₁₀ size fraction and can lead to elevated mass concentrations. As a result, both PM₁₀ and PM_{2.5} mass (and also PM_{10-2.5} mass) measurements and any speciation of PM mass at near-road sites can be very informative in furthering the understanding of the concentrations, properties, and behavior of PM in the near-road environment.

Currently, a large majority of PM₁₀ mass measurements and a slight majority of PM_{2.5} mass measurements use filter-based, gravimetric analyses over a 24-hour sample collection period. Diurnal variations in traffic and meteorology can have a tremendous impact on near-road air quality that is not identifiable in 24-hour average measurements. Thus, continuous or semi-continuous (i.e., hourly or sub hourly) PM measurements provide useful information for near-

road applications. Continuous particle measurement methods include the use of Beta attenuation, Tapered Element Oscillating Microbalances (TEOMs), and optical (light scattering) measurements (e.g., nephelometry). However, care must be taken in choosing a sampling method. Optical PM mass samplers, for example, typically cannot detect particles less than approximately 0.2-0.5 μm in diameter. As such, these measurement devices may not detect or characterize a significant amount of the PM mass related to motor vehicle combustion emissions. In addition, some continuous PM samplers heat the inlet air prior to analysis. Since motor vehicle PM emissions contain a significant amount of semi-volatile organic compounds, these samplers may have the potential to underestimate the PM mass in the near-road environment by volatilizing organic PM prior to detection.

16.10 Carbon Dioxide (CO₂)

Fossil fuel combustion is the primary source of CO₂ emissions, with the transportation sector contributing about 33% of U.S. CO₂ emissions. CO₂ is of concern as the most important greenhouse gas contributing to climate change. Continuous CO₂ measurements are typically made using a non-dispersive infrared system with which sub hourly sampling duration can be achieved. CO₂ concentrations can be elevated near roads, so high resolution measurement methods with good precision (high signal to noise ratios) would be needed to quantify near road impacts to relative background concentrations.

16.11 Organic Carbon (OC)

OC is a complicated mixture of thousands of individual molecules and is a combination of both primary particulate emissions and gaseous precursors that can form secondary aerosol. Some of the OC compounds, such as PAHs, are known or suspected carcinogens. OC is often

the largest component of PM in urban areas in the Western U.S. and especially in near-roadway environments. Motor vehicle fuel combustion is an important contributor of OC.

OC is typically measured by collecting PM on filters and then thermally quantifying the OC portion of the PM. These measurements are most commonly performed daily but continuous instruments that allow for 1-hr time resolution are in use. Other sources of OC exist in urban areas (such as wood smoke, industrial processes, biogenic emissions). Little is known about OC concentration gradients from roadways; however emissions from motor vehicles usually dominate these sources in near-road air quality.

To further investigate the OC mass, samples can be collected and analyzed for a wide range of organic species. These organic PM samples are most often collected on filters backed by a cartridge to collect gas-phase constituents. Sample collection typically uses high-volume samplers to maximize the amount of PM mass obtained for detailed chemical and physical analysis; thus, collection times can be from 24-hours to over a week, or samples are consolidated, to collect an ample amount of mass. Detailed speciation of organic PM compounds present in near-road samples can be useful in conducting or evaluating source apportionment studies to estimate the impacts of traffic emissions on near-road PM concentrations, although the long sample averaging times required for this analysis may limit the ability to discern differences in vehicle activity on organic PM air quality impacts. Alternatively, higher time resolution measurements can be made with instruments such as the high resolution aerosol mass spectrometer (HR-AMS), where, for example, 2-minute resolved data can be gathered. While specific molecules are not quantified, the amount of primary versus secondary OC can be quantified, and as well as local versus regional influences.

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